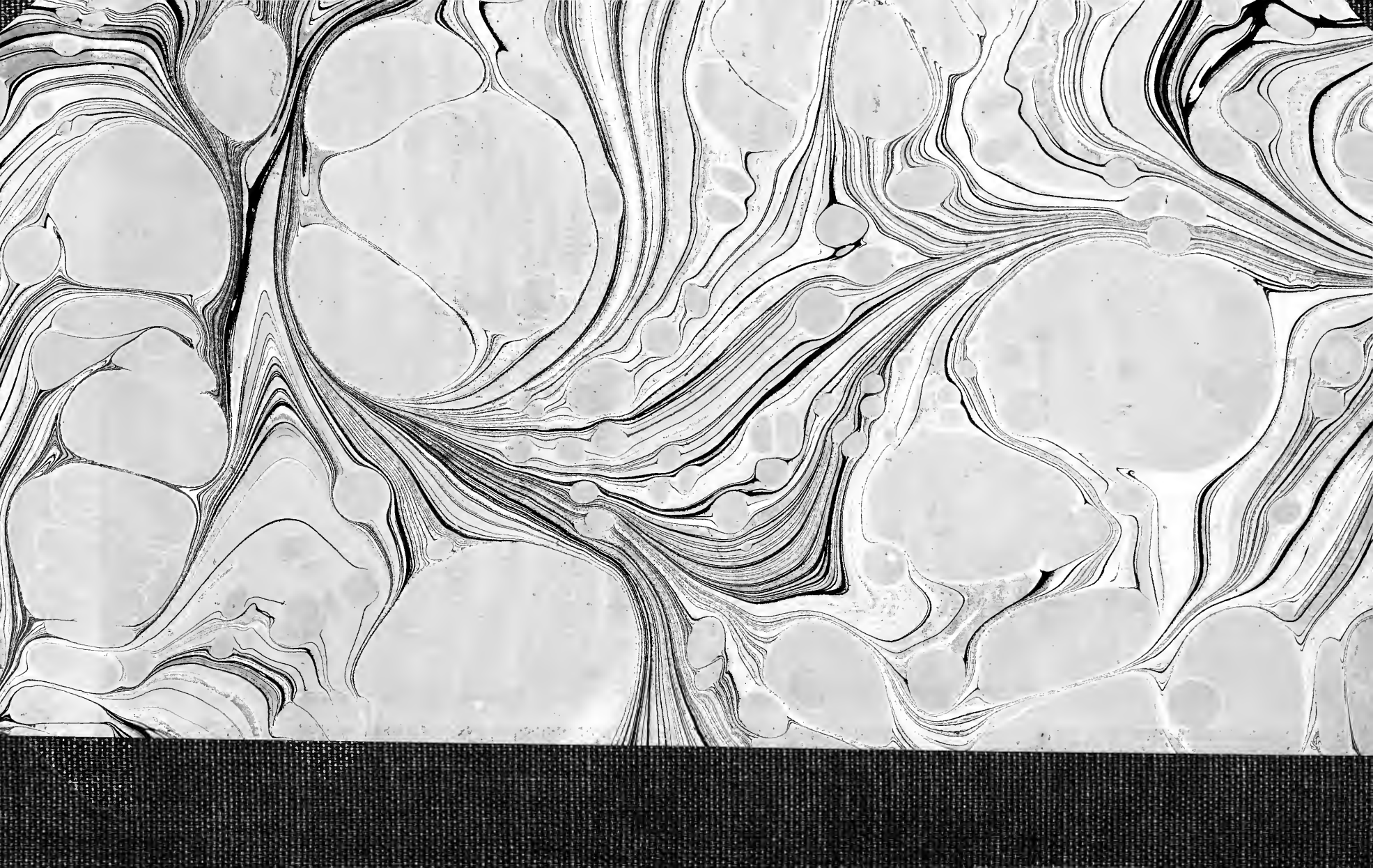
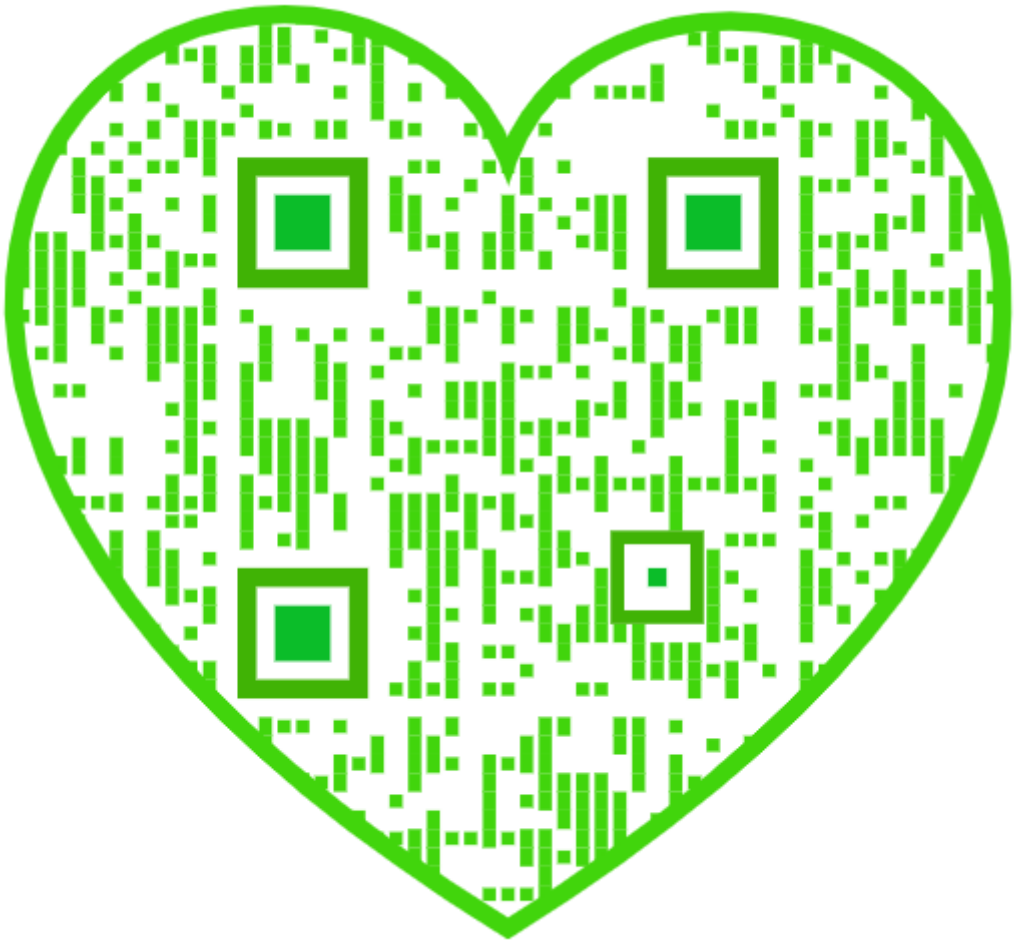




Digitized by the Internet Archive
in 2010 with funding from
Open Knowledge Commons and Harvard Medical School

http://www.archive.org/details/nitrousoxideoxyg00mcme

NITROUS OXIDE-OXYGEN ANALGESIA AND ANAESTHESIA IN NORMAL LABOR AND OPERATIVE OBSTETRICS

THIS MONOGRAPH BELONGS

TO

NITROUS OXIDE-OXYGEN ANALGESIA AND ANAESTHESIA IN NORMAL LABOR AND OPERATIVE OBSTETRICS

F. H. McMECHAN, M. D., *Editor*

Publication Committee

HERBERT C. ALLEN, M.D.
ARTHUR E. GUEDEL, M.D.
WILLIAM I. JONES, D.D.S.
WM. HAMILTON LONG, M.D.
CHARLES E. TURNER, M.D.
PAUL APPLETON, M.D.
W. C. DANFORTH, M.D.
C. HENRY DAVIS, M.D.
JOHN H. EVANS, M.D.
E. I. McKESSON, M.D.

A MONOGRAPH PREPARED FOR THE BENEFIT OF ALL THOSE CONCERNED IN SAFER AND MORE EFFICIENT OBSTETRICS AND ANAESTHESIA

PUBLISHED BY THE

NATIONAL ANAESTHESIA RESEARCH SOCIETY

BOSTON MEDICAL
MAY 1 0 1922
LIBRARY

25. A. 491

COPYRIGHT 1920 BY THE
NATIONAL ANAESTHESIA
RESEARCH SOCIETY

UFFERING during Labor is but the Tide in the Ocean of Motherhood and the Desire of Mothers is Eutocia, not Amnesia ❧ The Belief that Pain is an Inevitable Accompaniment of Labor has Reconciled Mothers to Endure It, while the Joy of Successful Motherhood has Caused Them to Forget It ❧ There is, however, no Logical Reason why Women Should Suffer During Labor ❧ Surgeons will Not Permit Their Patients to Suffer During an Operation ❧ Suffering, Physical and Mental, Produces Surgical Shock ❧ It Increases the Danger of Puerperal Complications and Delays Convalescence ❧ The Suffering can be Relieved and with Perfect Safety to Both Mother and Child ❧

—*C. Henry Davis.*

THIS MONOGRAPH HAS BEEN GIVEN ITS DISTINCTIVE TYPOGRAPHICAL SETTING BY THE HANN & ADAIR PRINTING CO., COLUMBUS, OHIO, UNDER THE SUPERVISION OF W. P. M'CAUL, FROM DESIGNS SUGGESTED BY THE EDITOR AND THE EXECUTIVE SECRETARY.

THE NATIONAL ANAESTHESIA RESEARCH SOCIETY, in presenting this Monograph for the consideration of the profession, wishes to thank, in an especial manner, the obstetricians and anaesthetists who have co-operated in acting as the Committee on Publication. The Society also feels deeply grateful to all those who have permitted the inclusion of their researches and clinical results. It is by such unified and co-operative efforts, as this Monograph, that progress, in any phase of a specialty, may be permanently recorded. The Monograph has been prepared for the benefit of all those concerned in safer and more efficient obstetrics and anaesthesia.

It is the intention of The National Anaesthesia Research Society to issue, from time to time, other Monographs, on the application of anaesthesia and analgesia to other specialties in the practice of medicine and dentistry.

Bound copies of this Monograph are obtainable from the office of the Executive Secretary, at $2.50 each.

Readers of this Monograph will no doubt be interested in knowing more about The National Anaesthesia Research Society, so the following details are given regarding its organization, purposes, control and activities:

The Society was organized by forward-looking manufacturers of anaesthetics and apparatus to provide a limited financial foundation for the following objects:

1. To promote the science of anaesthesia and to enable the members of the Society, and others, to submit to the dental and medical professions any views, findings or accomplishments they have attained.

2. To obtain from all available sources, information concerning any material, liquid or gas, known to have anaesthetic properties.

3. To arrange in co-operation with dental, medical and anaesthesia associations for the preparation and delivery of suitable, interesting and educational papers on the general subject, or relative to some particular anaesthetic.

4. To use its influence to avoid the publication or circulation of any false or unauthentic statements concerning the science or practice of anaesthesia, or about any anaesthetic.

5. To receive and tabulate reports of any and all conditions, symptoms or phenomena prevailing during or after anaesthesia by any anaesthetic and to prepare and distribute, on request, forms on which such information can be tabulated with uniformity.

6. To distribute by pamphlet or publication, as its funds may permit, such reliable data as may be collected or obtained from those interested in the subject.

7. To aid, as far as possible, in the preparation, publication and sale of suitable text books on the subject of anaesthesia, and to prepare as rapidly as possible, reference books for use by the medical and dental professions.

8. To co-operate with the state authorities in the preparation of suitable legislation to safeguard those to whom an anaesthetic is to be administered, as well as those called upon to administer it.

9. To arrange for the production of moving picture films to illustrate to the profession the action of anaesthetics on the patient during induction and maintenance of anaesthesia, and to prepare articles for publication in magazines and the public press.

10. To use its influence in every possible way and to give its aid toward the advancement of the science, practice and teaching of anaesthesia.

Any individual holding a degree of Doctor of Medicine or Doctor of Dental Surgery from a duly recognized college or university, or a Doctorate of similar standing in Science or Research, shall be eligible for professional membership in this Society.

The annual dues for membership in this Society are $2.00, payable in advance.

The Board of Governors, controlling the activities of the Society, is composed of the following members: Stephen Morris, President, Philadelphia; J. G. Sholes, Vice-President, Cleveland; B. J. Clark, Secretary-Treasurer, Minneapolis; E. I. McKesson, M. D., Toledo; F. H. McMechan, M. D., Chairman of the Research Committee, Avon Lake, O.; and W. I. Jones, D. D. S., Secretary of the Research Committee, Columbus, O.

The Society has indeed been fortunate in securing the co-operation of the following as Members of its Research Committee: Wm. Seaman Bain-

bridge, M. D., New York City, John J. Buettner, M. D., Syracuse, N. Y., Charles Baskerville, Ph. D., New York City, Wm. E. Burge, M. D., Urbana, Ills., S. Griffith Davis, M. D., Baltimore, Md., Wm. Harper DeFord, D. D. S., Des Moines, Ia., A. F. Erdman, M. D., Brooklyn, N. Y., John H. Evans, M. D., Buffalo, N. Y., G. M. Geldert, M. D., Ottawa, Canada, Arthur E. Guedel, M. D., Indianapolis, Ind., Yandell Henderson, Ph. D., New Haven, Conn., Isabella C. Herb, M. D., Chicago, Ills., Roy S. Hopkinson, D. D. S., Milwaukee, Wis., Wm. B. Howell, M. D., Montreal, Canada, Oel E. Lanphear, D. D. S., Kalamazoo, Mich., Wm. Hamilton Long, M. D., Louisville, Ky., Frank C. Mann, M. D., Rochester, Minn., A. H. Miller, M. D., Providence, R. I., John Osborn Polak, M. D., Brooklyn, N. Y., S. P. Reimann, M. D., Philadelphia, Pa., Everett A. Tyler, M. D., Philadelphia, Pa., Fred L. Wallace, D. D. S., Philadelphia, Pa., Samuel Johnston, M. D., Toronto, Canada and Wesley Bourne, M. D., Montreal, Canada.

The National Anaesthesia Research Society has recently drafted a uniform Anaesthesia Record, through the activities of a sub-committee composed of Drs. A. H. Miller, E. I. McKesson, A. F. Erdman and F. H. McMechan. This record is ready for distribution and it is hoped that anaesthetists and hospitals will use it so that large series of administrations may become available for study, and a nation-wide safety-first movement in anaesthesia may be initiated to more adequately protect the lives and speed the recoveries of all patients coming to operation.

For further information, membership and publications of the Society address

T. T. FRANKENBERG, *Executive Secretary*,
16 East Broad St., Columbus, Ohio.

UCH OF THE INCREASE OF MATERNAL MORTALITY WILL BE FOUND IN THE MISUSE OF ANAESTHESIA AND IN THE RIDICULOUS PARODY, WHICH IN MANY PRACTITIONERS' HANDS, STANDS FOR THE USE OF ANTISEPTICS ❧ IN A WORD, THE USE WHICH HAS BEEN MADE, BY MANY, OF THE TWO GREATEST BLESSINGS OF HUMANITY, HAS CONVERTED THEM INTO LITTLE ELSE THAN A CURSE ❧ BEFORE THE DAYS OF ANAESTHESIA INTERFERENCE WAS LIMITED AND OBSTETRICAL OPERATIONS WERE AT A MINIMUM, BECAUSE INTERFERENCE OF ALL KINDS INCREASED THE CONSCIOUS SUFFERING OF THE PATIENT ❧ WHEN ANAESTHESIA BECAME POSSIBLE AND INTERFERENCE BECAME MORE FREQUENT, BECAUSE IT INVOLVED NO ADDITIONAL SUFFERING, OPERATIONS WERE UNDERTAKEN WHEN REALLY UNNECESSARY, ON THE DEMAND OF THE PATIENT OR FOR THE CONVENIENCE OF THE PRACTITIONER ❧ AND SO COMPLICATIONS AROSE AND THE DANGERS OF LABOR INCREASED * * * WHEN THE PRACTICAL OBSTETRICIAN REALIZES HIS RESPONSIBILITY AND THAT NO SMALL SHARE OF THIS TERRIBLE MATERNAL MORTALITY, OF A CERTAINTY, LIES AT HIS DOOR, HE HAS MADE THE FIRST STEP TOWARD TRUE PROGRESS ❧ WHEN HE REALIZES THAT LABOR IS A NATURAL PROCESS, WHICH, IN THE GREAT MAJORITY OF CASES, IT IS CRIMINAL TO DISTURB; WHEN HE REALIZES THAT EVERY INTERFERENCE INCREASES THE INHERENT DANGERS A HUNDRED-FOLD; AND WHEN, UNDER THIS CONSCIOUSNESS, HE BRINGS WITH HIM TO THE LYING-IN ROOM ALL THAT IS POSSIBLE OF THOSE PRINCIPLES OF ANTISEPTIC AND ASEPTIC SURGERY, AS WELL AS MODERN METHODS OF ANAESTHESIA, WHICH HAVE BEEN AT THE BOTTOM OF THE TRIUMPHS OF MODERN GYNECOLOGY, WE SHALL NOT HAVE LONG TO WAIT FOR THE LIGHTENING OF THE DARK CLOUD WHICH HANGS OVER US NOW ❧

—*Milne Murray*

TABLE OF CONTENTS

CHAPTER ONE

	PAGE
The Historical Evolution of Nitrous Oxide Analgesia and Anaesthesia in Obstetrics	1
The Experiences of Klikowitsch and Winckle	1–2
The Revival of the Method by Webster, Davis, Guedel, Allen and Others	3
Effects of Civilization on Child-Bearing Women	4
Failure of Anaesthesia and Antisepsis to Decrease Obstetrical Morbidity	4
Views of Milne Murray	4–5

CHAPTER TWO

The Necessary Qualifications for a Universally Satisfactory Obstetrical Analgesic and Anaesthetic	7
Mistakes in the Revival of Nitrous Oxide	8
The Vital Preliminary Knowledge of the Physio-Pathology of Nitrous Oxide	8
Safety, Efficiency, Harmlessness and Flexibility of Nitrous Oxide	8–9
Rapidity of its Elimination	9
Its Comparative Value	9–10

CHAPTER THREE

Chloroform in Labor	11–12
The Use of Pituitrin to Offset Uterine Inertia	12–13
The Studies of H. C. Davis in the Relative Toxicity and Efficiency of Chloroform, Ether and Nitrous Oxide	13
Discussion of Findings	13–15
Choice of Anaesthetic during Pregnancy	15–16
Choice of Anaesthetic in Labor	16
General Conclusions	16–18
Levy's Views on Chloroform Fibrillation and its Dangers	18

CHAPTER FOUR

	PAGE
Blood Changes under Anaesthesia and Analgesia	19–20
Decrease of Blood Catalase by Various Anaesthetics	20–22
Nitrous Oxide-Oxygen and the Alkali Reserve	22–23
Circulatory Disturbances	23–24
Further Experimental Studies on the Effects of Anaesthetics in Shock	24–26
Blood Pressure Reactions as an Index of the Patient's Resistance, Operative Shock and the Degrees of Circulatory Depression	26–27
Relation of Muscular Relaxation to Circulatory Depression	27
Contra-Indications	27–28

CHAPTER FIVE

Essentials of Ideal Obstetrical Analgesia	29–30
Fundamental Considerations: Effects of Analgesia on the Special Senses	30–31
Guiding Signs During Intermittent and Continuous Analgesia	31–32
Various Mixtures of Nitrous Oxide, Air and Oxygen	32
Pointers in the Administration of Obstetrical Analgesia	32–33
The Method of Self-Administration and Co-operation of the Patient	33–34
Controlling the Depth and Speed of Analgesia	34
Charting the Varied Methods of Analgesia	35–36
Anticipating Uterine Contraction	36–37
Lapses into Anaesthesia during Continuous Analgesia	37–39
Devices for Facilitating the Administration of Analgesia	39

CHAPTER SIX

Nitrous Oxide-Oxygen Obstetrical Anaesthesia	41–42
The Guiding Signs and Symptoms for Light, Normal and Profound Anaesthesia	42
Indication for More Oxygen	42–44
The Normal Plane of Anaesthesia	44
Technique of Administration	44–45
The Zones of Analgesia and Anaesthesia Without Supplemental Narcosis	45–46
The Question of Rebreathing	46–49
Clinical Application of Rebreathing	49

PAGE

Effects of Rebreathing 49–50
Opinions on Rebreathing in Obstetrical Analgesia and Anaesthesia 50–51

CHAPTER SEVEN

Further Effects on Mother and Child 53
Control of Headache, Nausea and Vomiting 53
Conservation of Muscle Tone 54
Protection Against Haemorrhage, Acidosis and Bacterial Invasion 54–55
Physical Well-Being of Mothers after Labor 55–56
The Reactions of Varying Types of Patients 56
Handling Difficult Patients 56–57
Primiparae and Multiparae 57
Effects of Nitrous Oxide Anaesthesia and Analgesia on the Child 57–58
Mechanism of Protection 58
Cyanosis, Pink and Blue Babies 58–59
Early Flow of Milk and Conservation of Weight 59
Minimal Effects on the Unborn Child 59–60
Time Limit of Administration 60–61
Nitrous Oxide no Panacea for Poor Obstetrics 61

CHAPTER EIGHT

Davis's Statistical Analysis of his Results 63–64
Forceps and Pituitrin 64
Average Stay in Hospital 64
Duration of Labor 64
Weight of Babies at Birth 64–65
Lacerations 65
Mortality 65
Postpartum Haemorrhage 65
Discussion and Conclusions 65–67
Records and Results of Cherry 67–68
Danforth's Experiences 68–69
Method of Administration 69
Details of Results 69–70
Condition of Babies at Birth 70–71
Puerperal Insanity 71–72
Other Available Statistics 72–74

CHAPTER NINE

	PAGE
Nitrous Oxide-Oxygen in Operative Obstetrics	75
General Considerations	76–77
Pathological Conditions of Patients as Complicating Factors of Pregnancy, Labor and Operative Obstetrics	78
Operations During Pregnancy	78
Gall-Bladder Operations	78
Appendicitis and Pelvic Infections	78–79
Tumors	79
Abortions, Miscarriages and Ruptured Ectopic Gestations	79–80
Heart Lesions	80
Tuberculosis	80–81
Sapraemia and Sepsis	81
Syphilis	82
Nephritis, Eclampsia and Toxemia	82–83
Supplemental Etherization	83
Precipitate Labor and Uterine Inertia	83–85
Rigid Perineum and Episiotomy	85–86
Forceps Delivery and Version	86–87
Repairs	87–88
Nitrous Oxide-Oxygen and Combined Anaesthesia for Caesarean Section	88–90
Alkaloidal Medication	90–91
By Whom Shall Nitrous Oxide Analgesia and Anaesthesia be Administered	91–94
Conclusions	94

APPENDIX

References to the Recent Literature on Nitrous Oxide-Oxygen in Normal Labor, Operative Obstetrics and Research	95–97

BOSTON MED
MAY 1 0 192

CHAPTER ONE
Historical Evolution

The Historical Evolution of Nitrous Oxide Analgesia and Anaesthesia in Obstetrics ❧ The Experiences of Klikowitsch and Winckle ❧ The Revival of the Method by Webster, Davis, Guedel, Allen and Others ❧ Effects of Civilization on Child-Bearing Women ❧ Failure of Anaesthesia and Antisepsis to Decrease Obstetrical Morbidity ❧ Views of Milne Murray ❧

HISTORICALLY NITROUS OXIDE in obstetrics was recommended by the French savant, Paul Bert, in 1878. Following his suggestion, Klikowitsch of Petrograd, in 1880, reported 25 cases of labor in which he had used laughing gas with satisfactory results. Then came reports by Tittle, in 1883; Doederlein, in 1886, and Hillischer, in 1887. Clifton Edgar, of New York City, in 1890, in his English edition of Winckle's Text-Book of Midwifery, first brought this matter to the attention of American obstetricians and anaesthetists.

The Experiences of Klikowitsch and Winckle.—Pioneering with crude and inadequate apparatus, Winckle thus describes his experiences:

"Narcosis by means of laughing gas is not dangerous and may be discontinued at the will of the parturient woman; it mitigates the pain in proportion to the intelligence of the person, as stupid persons often withstand its influence for a long time before its favorable effect is felt. In most persons its inhalation produces a state of intoxication for a short time with a tendency to laughter. Women, to whom it is not administered until the stage of expulsion, can seldom be induced to inhale it quietly, while when it is administered in the first stage of labor its beneficial action is at once felt and extends to the second stage. It is especially useful in primiparae."

In speaking of his clinical results, Winckle continues: "The pulse of the parturient woman is usually slowed considerably by laughing gas, but finally reaches its original rate again. The child's pulse is also slower in 8 per cent of cases, but it usually seems to be more frequent. The woman's temperature often rises 0.7 of a degree. At first the pupils are somewhat contracted. The pains are not the same in strength or duration, but are often more frequent and stronger, and existing vomiting often ceases. Klikowitsch and I have both observed aphasia; and once in 50 cases an hystero-epileptic attack was caused; and in another instance a real epileptic seizure followed its use; but otherwise no bad effects were observed, either as regards the mother or the child. * * *

"The oxygen of the blood remains in normal combination, while the nitrous oxide probably circulates in much looser chemical combination in the blood, absorbed by the plasma. These researches should be supplemented by the observations of others and were, by no means, thought conclusive by us, as Doederlein believes. * * *

"It seems to me most practical to get the mixture from the apothecary, as was formerly the case, and that he should be provided with rubber bags, which he may fill and furnish the physician when needed. In this manner the gas might be introduced into private practice and would not be monopolized by the clinics. A number of interesting problems attach to its use, but we refrain from discussing them. The apparatus, which consists of a rubber bag like a pillow, is inconvenient, but in abnormally painful labor it is, at any rate, an extremely important remedy."

Arthur E. Guedel, of Indianapolis, suggests that while no mention was made of *analgesia*, in the reports of these early investigators, it is probable that they were working under an imperfect analgesia or light narcosis, not recognizing the difference between the two states. C. Henry Davis, of Milwaukee, concludes that owing to its cost, the impurity of the gas secured, the crudeness of the apparatus used, and the fact that nitrous oxide was often given to the stage of asphyxia, it was not surprising that this method of narcosis did not come into routine use at that time. When it is further realized that Hewitt, of London, following the initiative of Hillischer, of Vienna, spent many years in perfecting a more satisfactory nitrous oxide apparatus and in developing a dependable technique of administration, it becomes all the more apparent why the efforts of these pioneers came to naught.

THE REVIVAL OF THE METHOD BY WEBSTER, DAVIS, GUEDEL, AND OTHERS.—The resumption of the use of nitrous oxide in obstetrics followed close upon the perfecting of the technique of and apparatus for nitrous oxide-oxygen analgesia and anaesthesia in dentistry and general surgery. In 1909, Davis administered nitrous oxide-oxygen for J. Clarence Webster, of Chicago, when he performed his first Caesarean section under this anaesthetic. During the same year, Davis writes: "We gave this anaesthetic for all types of operative obstetrics, and in one primipara gave the gas for about two hours prior to a forceps delivery. Although at that time we appreciated the value of nitrous oxide-oxygen in obstetrical practice, its use was limited to the end of the second stage of labor, as the hospital was not willing to bear the supposedly excessive cost of its prolonged administration."

In 1910, Guedel began the routine administration of nitrous oxide analgesia and anaesthesia, as we now understand it, in normal labor and operative obstetrics.

In 1912, Herbert C. Allen, of Brooklyn, reported favorably on its use in the Maternity Department of the Homoeopathic Hospital. He found the method of especial value in multiparae, who had had the comparison of previous labors to appreciate the pain-relief of nitrous oxide. Allen also observed some excitement and difficulty of control in alcoholics and drug addicts.

Since 1912, when Guedel presented his apparatus for and described his technique of *self-administration* to the New York Society of Anaesthetists, the method has come into vogue and, at the present time, is being given a thorough try-out by the leading obstetricians and anaesthetists of the United States. As early as 1915, Guedel was able to report 1,800 collected cases; while in 1917, R. Ferguson, of Chicago, summarized, before the American Association of Anaesthetists, the conflicting opinions and the results of many users from their accumulated experiences in 8,000 administrations. These rapidly mounting figures evinced the interest of the profession and public alike in this newer method of relieving the pains of labor.

It is needless, at this late day, to revert to the intense theological opposition which raged against Sir James Y. Simpson, of Edinburgh, when he first used ether in labor and later popularized chloroform *a la reine*, with the *cachet* of Queen Victoria. Suffice it to say that the profession at large as well as the public is now a unit in demanding the relief of pain during labor.

The Effects of Civilization on Child-Bearing Women.—Civilization, with its artificial dress and customs, has rendered women more or less hot-house products and physically less fit to perpetuate the race. Thirty years ago Lusk warned us that: "As the nervous organization loses in the power of resistance, as the results of higher civilization and artificial refinements, it becomes imperatively more necessary for the physician to guard parturient women from the dangers of excessive and too prolonged suffering." Supplementing Lusk, Davis contends that: "Among civilized women easy and painless childbirth is not rare, but most women are in labor several hours and unaided endure considerable and often very severe pain. Suffering during labor is but the tide in the ocean of motherhood and the desire of mothers is *eutocia* not *amnesia*. The belief that pain is an inevitable accompaniment of labor has reconciled mothers to endure it, while the joy of successful motherhood has caused them to forget it. There is, however, no logical reason why women should suffer during labor. Surgeons will not permit their patients to suffer during an operation. Suffering, physical and mental, produces surgical shock; it increases the danger of puerperal complications and delays convalescence. The suffering can be relieved and with perfect safety to both mother and child."

The Failure of Anaesthesia and Antisepsis to Decrease Obstetrical Morbidity.—In this connection it must be emphasized that the use of obstetrical analgesia or anaesthesia *alone* will not materially alter the present morbidity of labor. With all the advancement in the science of obstetrics, in this age of low surgical mortality and preventive medicine, why is maternity so dangerous? Why has there been a slight increase in the number of deaths from puerperal sepsis and other obstetrical complications since the discovery of anaesthesia and antisepsis? Probably Milne Murray has best answered this query, when he said:

Views of Milne Murray.—"I feel sure that an explanation of much of the increase of maternal mortality, from 1847 onward, will be found first, in the misuse of anaesthesia, and second, in the ridiculous parody which, in the hands of many practitioners, stands for the use of antisepsis. In a word, the use which has been made, by many, of two of the greatest blessings of humanity, has converted them into little else than a curse. Before the days of

anaesthesia interference was limited and obstetrical operations were at a minimum, because interference of all kinds increased the conscious pain of the patient. Thus forceps and turning were employed only when natural efforts had failed and such operations, as the artificial dilatation of the rigid os, were not attempted until they became an urgent necessity. With anaesthesia interference became more frequent, because it involved no additional suffering, and operations were undertaken when really unnecessary, on the demand of the patient or for the convenience of the practitioner. And so complications arose and the danger of labor increased. * * * *

"Then came the antiseptic era. Here was now the panacea for all the dangers of childbed. All that was necessary was to dip the instruments, for a few minutes, in a carbolic lotion and the hands in one of half the strength for half the time, and all the danger was at an end. The forceps were passed through an undilated os; if it tore slightly, no matter, the antiseptic made that quite safe. Turning was now a matter of mere manipulative skill—a clean hand in the uterus could do no harm. This is no mere caricature; and if it represents the methods of any reasonable proportion of practitioners, what wonder the cup was so often filled with death? * * * *

"Normal labor is a natural process which is best left to itself, and the less the patient is disturbed with the paraphernalia of obstetrics, before or after, the better. Until men realize this and recognize the fact that the simplest obstetrical operation demands not one whit less of care as to antiseptic precautions than is required of one before opening the abdomen, we shall get no further forward. * * * *

"*When the practical obstetrician realizes his responsibility and that no small share of this terrible maternal mortality, of a certainty, lies at his door, he has made the first step towards true progress. When he realizes that labor is a natural process, which, in the great majority of cases, it is criminal to disturb; when he realizes that every interference increases the inherent dangers a hundred-fold; and when under this consciousness he brings with him to the lying-in room all that is possible of those principles of antiseptic surgery which have been at the bottom of the triumphs of modern gynecology, we shall not have long to wait for the lightening of the dark cloud which hangs over us now.*"

NY Single Anaesthetic or Method, Which will Prove Universally Satisfactory in Labor and Operative Obstetrics, Probably will Never be Found ¶ The Necessary Qualifications of Such an Agent, Applied as our Present-Day Obstetrics Indicate, are Many ¶ It Should Have no Ill Effect, Immediate or Remote, on either the Mother or the Babe ¶ It should Render True, Physical Relief from Suffering and should be Applicable over a Long Period of Time Without any Influence upon Uterine Contraction ¶ It must Present to the Obstetrician a Patient in Satisfactory Condition for Delivery and to be Entirely Practical it must Admit of Convenient, Simple and Economical Use ¶ Of all the Various Anaesthetic Agents now at our Command, Nitrous Oxide is Probably the Most Nearly Adapted to the Fulfillment of these Qualifications.

—*Arthur E. Guedel.*

CHAPTER TWO
General Considerations

The Necessary Qualifications for a Universally Satisfactory Obstetrical Analgesic and Anaesthetic ❧ Mistakes in the Revival of Nitrous Oxide ❧ The Vital Preliminary Knowledge of the Physio-Pathology of Nitrous Oxide ❧ Safety, Efficiency, Harmlessness and Flexibility of Nitrous Oxide ❧ Its Rapid Elimination and Value Compared with Chloroform and Ether ❧

ALTHOUGH REVIVED FOR USE at a time when it had to compete with chloroform and ether anaesthesia, as well as with scopolamine-morphine amnesia, nitrous oxide-oxygen had to overcome and win its way in spite of the most critical observations of its relative merits and its comparative safety.

The Necessary Qualifications for a Universally Satisfactory Obstetrical Analgesic and Anaesthetic.—"Any single anaesthetic agent," says Guedel, "which will prove universally satisfactory in all cases of obstetrics probably will never be found. The necessary qualifications of such an agent, applied as our present-day obstetrics indicate, are many. It should have no ill effect, immediate or remote, on either the mother or the babe. It should render true, physical relief from suffering and should be applicable over a long period of time without any influence upon uterine contraction. It must present to the obstetrician a patient in satisfactory condition for delivery and to be entirely practical it must admit of convenient, simple and economical use. Of all the various anaesthetic agents now at our command, nitrous oxide is probably the most nearly adapted to the fulfillment of these qualifications."

In spite of the variety of techniques and apparatus employed, the combinations of gases utilized and the length of time during which analgesia and

anaesthesia were maintained, the results, from 10,000 collected cases, have been so preponderantly favorable, that the untoward incidents, recorded in a few cases, serve principally to emphasize the mistakes that have been made and to point the way to obviating their recurrence.

MISTAKES IN THE REVIVAL OF NITROUS OXIDE.—F. H. McMechan, of Avon Lake, Ohio, has pointed out that: "Unfortunately the initial revival of interest in nitrous oxide anaesthesia and analgesia for surgery and dentistry, some years ago, was almost wrecked by the stubborn ignorance of many administrators, who thought that an automatic apparatus solved all problems of technique and who were too slothful to study the theory and practice of narcosis. The present recrudesence of interest, however, is established on the firmer foundation of scientific research and clinical achievement; and while the educational facilities, for acquiring expert knowledge of nitrous oxide analgesia and anaesthesia, are not yet entirely what they should be, earnest efforts are being made to offer courses and clinical instruction in these subjects that will enable those who desire to fit themselves as competent anaesthetists."

This Monograph has been undertaken to provide all those interested with an exhaustive survey of what has been and may be accomplished by nitrous oxide analgesia and anaesthesia in normal labor and operative obstetrics; and if it succeeds in promoting further investigations and in extending clinical use, it will have accomplished more than the National Anaesthesia Research Society's anticipations.

THE VITAL PRELIMINARY KNOWLEDGE OF THE PHYSIO-PATHOLOGY OF NITROUS OXIDE.—In passing, it should be emphasized that the obstetrician or anaesthetist who uses this newer method for the relief of labor pains, without first grounding himself thoroughly in its physio-pathology and the technique of administration, is not doing himself, his patients and the method the justice they deserve. In anaesthesia, as in all other arts and sciences "a little learning is a dangerous thing!" Only those who drink deeply of the inexhaustible spring of knowledge eventually succeed.

SAFETY, EFFICIENCY, HARMLESSNESS AND FLEXIBILITY OF NITROUS OXIDE.—Of the general anaesthetics in common use nitrous oxide is the least harmful in its immediate effects upon metabolism. Recovery, after its admin-

istration, is decidedly prompt and usually without post-operative complications such as retching, vomiting and toxaemia. Nitrous oxide is rapidly eliminated from the system and has, comparatively a negligible effect upon the blood, tissues and organs of the body, all of which resume their normal function very shortly after the discontinuance of its administration. The advantages of the non-asphyxial method of administration may be briefly summarized as follows: The paramount safety of nitrous oxide (with the required mixture of air or oxygen) as a general anaesthetic agent, in proper hands, is an established proposition—the facts prove it. Its planes of anaesthesia and analgesia are far more accurately controllable than those of any other form of narcosis. During its non-asphyxial administration the operator has equally at his command the analgesic state, in which the patient is conscious but relieved of pain, and profound narcosis, when every sense is stilled in letheon forgetfulness; and either stage can be prolonged indefinitely or readily transformed into the other without untoward complications.

RAPIDITY OF ITS ELIMINATION.—E. I. McKesson, of Toledo, considers nitrous oxide the ideal agent for the relief of pain in labor, because it is inhaled like air, is practically odorless, almost instantaneous in its action on the patient, and is eliminated so quickly that the gas has left the body by the time the next pain is due. "It is difficult," continues McKesson, "to conceive of an agent which can be used to treat *each individual pain*, so that at any moment of labor, when more suffering occurs, a greater dosage of the analgesic can be instantly administered, or with less pain it may be reduced at once; yet this is precisely what can be done with nitrous oxide. * * * The flexibility of nitrous oxide analgesia distinguished it from *twilight sleep* or any other form of hypodermic alkaloidal amnesia, in which the dose is slow to act and cannot be withdrawn if it is too large. Chloroform is the closest approach to nitrous oxide in flexibility, but its action is not fast enough to relieve a pain which is beginning when its inhalation is started and it is so slow in its elimination that all traces of the chloroform will not disappear for many hours."

ITS COMPARATIVE VALUE.—"The reason nitrous oxide acts so quickly, as compared to chloroform or ether, is because it is held in the body in an aqueous solution, which is the normal medium in which oxygen and all food products enter the cell; it follows the natural course of gaseous exchange in the

body. Moreover, nitrous oxide analgesia and anaesthesia may be almost immediately modified by the admixture of air or oxygen. Ether and chloroform must first saturate, to a certain extent, the fats of the body before analgesia or anaesthesia can be produced. After the fats have absorbed ether or chloroform the lipoid-affinity for these agents prevents or delays their elimination for hours and days, which accounts for the nausea, vomiting, acetonuria and delayed poisoning following their administration. With the lipoid-solvent anaesthetics the air or oxygen admixture is a secondary factor in determining the depth of anaesthesia, *the determining factor being the actual vapor tension of such agents dissolved in the neuron.*"

CHAPTER THREE
Relative Evaluation

Chloroform in Labor ❧ The Use of Pituitrin to Offset Uterine Inertia ❧ Davis's Studies in the Relative Toxicity and Efficiency of Chloroform, Ether and Nitrous Oxide-Oxygen Anaesthesia and Analgesia in Pregnancy and Labor ❧ Discussion of Findings ❧ Choice of Anaesthetic During Pregnancy and Labor. General Conclusions ❧ Dangers of Chloroform Fibrillation ❧

RECENTLY THE DISCUSSION between certain research workers and clinicians, regarding the immediate and remote effects of chloroform analgesia and anaesthesia, has reached a crucial state. It was to meet the criticism of certain physio-pathologists, that obstetricians were among the worst offenders in promoting delayed chloroform poisoning, that I. Hill, of New York City, undertook experiments on dogs and guinea pigs to determine if the obstetrical method of administering chloroform would lead to the usual pathological results. Contrary to Hill's expectations the halogen changes in the liver were found, as well as the same tendency to rapid regeneration.

Chloroform in Labor.—Hill offers the following explanation of his experimental results:

"Although planned theoretically to imitate the narcosis of childbirth, my anaesthetization of these animals did not, in fact, resemble it at all. The animals were strapped to boards, where they strained for a considerable period until they finally became drowsy from exhaustion or somnolent from the effect of the anaesthetic. There was no *euphoria* in these animals. A woman in labor has suffered pains and fears their return. She believes chloroform will give relief. She receives an adequate inhalation during a pain. This is re-

peated with other pains. She anticipates relief from chloroform. The wonderful relief from small doses, in a small part, is due to its analgesic effect, in much larger part to a sort of hypnotism. * * * * Certainly the large doses of chloroform in proportion to the weight, given to a fear exhausted animal, are not comparable with the whiffs of chloroform given a healthy woman in a cheerful and receptive frame of mind. * * * * I have never seen any symptoms due to this narcosis, the so-called chloroform *a la reine*, and am inclined to take a position based on the evidence of the numerous competent clinical observers, who have reported favorably on it from their actual experience. * * *

"If we are reluctant to ignore the facts shown in animal experiments, we can accept the findings of the recent work of Evarts Graham, who has shown that alkalies, administered along with chloroform, inhibit its toxic effects on animals. If we are giving a protracted anaesthesia, we can give alkalies. * * *

"There have been objections to the use of chloroform in the second stage of labor by most textbook writers. * * * * In my experience practically all objections to chloroform on the ground of delaying contractions have disappeared since I have been using pituitary extract. Using ½ ampoule of pituitary extract every twenty-five minutes, during the administration of chloroform, in small doses at each pain, I find that labor progresses rapidly."

THE USE OF PITUITRIN TO OFFSET UTERINE INERTIA.—The use which Hill makes of pituitrin, to offset the effect of chloroform analgesia and anaesthesia, is corroborative evidence that when lipoid-solvent anaesthetics are inhaled in sufficient concentration to *really* relieve suffering, their paralytic action on muscle generally weakens the uterine contractions and slows their onset. Also the routine use of pituitrin, in the dosage suggested by Hill, remains, as yet, to be proven a safe procedure. With nitrous oxide the uterine contraction is allowed to *start* before the gas is inhaled, and analgesia is still produced rapidly enough to counteract the labor pain; *while uterine contraction, instead of being weakened by its effect, is actually stimulated.* The elements of suggestion and hypnotism should play no part in the perfected technique of nitrous oxide analgesia or anaesthesia in labor. Actual pain elimination without interference with the progress of labor can and should be obtained.

Undoubtedly chloroform, if given very discreetly and with indifferent pain-relief during labor, with concomitant alkalinization, may not be routinely

attended with untoward effects, but it is *not* used in this manner in the majority of cases and Fleming's coroners' statistics, presented to the Anaesthetic Section of the Royal Society of Medicine, show rather conclusively that in the hands of the general practitioner, chloroform anaesthesia involves a prohibitive immediate and remote mortality. Also chloroform analgesia and anaesthesia become increasingly dangerous in the presence of co-existent pathological states, systemic diseases and obstetrical complications.

THE STUDIES OF H. C. DAVIS IN THE RELATIVE TOXICITY AND EFFICIENCY OF CHLOROFORM, ETHER AND NITROUS OXIDE.—Davis, of Milwaukee, whose efforts to place obstetrical analgesia and anaesthesia on a scientific and clinical basis of safety and efficiency, deserve great commendation, recently presented his studies in "The Relative Toxicity and Efficiency of Chloroform, Ether and Nitrous Oxide-Oxygen Analgesia and Anaesthesia in Pregnancy and Labor," before the Fifth Annual Meeting of the American Association of Anaesthetists. His experiments and conclusions are entitled to extended consideration:

Davis was convinced that the extant literature showed a comparison of former studies of chloroform, ether and nitrous oxide-oxygen, that was open to much criticism, since the anaesthetics were administered under very different conditions, without sufficient controls; with the animals in unnatural positions, thereby being subjected to changes from shock; and the quantity of anaesthetic used was often excessive for the body weight of the animal. Therefore Davis constructed an anaesthetic chamber in which groups of *pregnant* and *non-pregnant* animals could be anaesthetized under very similar conditions. Experiments were conducted with chloroform-air; ether-air; nitrous oxide-oxygen analgesia and anaesthesia, and chloroform-oxygen. Each anaesthetic was administered in a vaporous or gaseous state. The concentration of carbon dioxide was limited by having a false floor three inches above the bottom of the box, under which was placed a solution of lime water or sodium hydrate, and having a ventilating valve near the bottom as well as in the top. The animals had perfect freedom, and their condition could be observed at all times through the glass door.

DISCUSSION OF FINDINGS.—Discussing his observations, Davis calls attention to a number of points reported in the most recent literature, which

support his own conclusions, which though not absolutely conclusive, are offered to stimulate further research:

The experimental results are in accord with those who find that chloroform is the most dangerous anaesthetic. They offer additional evidence that chloroform has a destructive action apart from interfering with oxidation in that it causes an actual necrosis of liver-cells. They indicate that with each of the anaesthetics there is more danger to the foetus *in utero* than to the mother. And since the young born to mothers which had only one hour of light anaesthesia with chloroform and pure oxygen in excess show markedly fatty livers, it is evident that the use of oxygen cannot remove the dangers of chloroform.

These experiments confirm the statements of Graham, Sansum, and Woodyatt: "Chloroform is prone to cause swelling of the cells, with fat infiltration, necrosis, and a haemorrhagic tendency. Ether has not been observed to cause necrosis, but it may produce milder forms of parenchymatous degeneration and tissue swelling. Nitrous oxide has little tendency to produce any visible tissue changes." This study suggests that nitrous oxide produces cell changes only by interfering with cell metabolism. The changes observed after both ether and nitrous oxide have all been of the type found after asphyxiation, yet the fact that a slower recovery is made after ether indicates that it causes a more severe injury than nitrous oxide. This, however, is only natural since ether enters into a close combination with the lipoids of the body and a considerable period is required for its elimination. Nitrous oxide has the power of quickly displacing oxygen, but it is eliminated with equal rapidity and therefore can interfere very little with cell metabolism beyond the period of anaesthesia.

It is the opinion of most laboratory investigators that any narcotic drug given in a sufficiently large dose will interfere with cell metabolism, and cause some degree of cell asphyxia with whatever degree of acid increase this implies. The livers of the pigs dying from chloroform poisoning, nitrous oxide asphyxia, and ordinary asphyxiation were all acid to dimethylamidoazobenzol. No reaction was obtained from short anaesthesias. It has long been known that glycosuria may occur after a long anaesthesia with some degree of asphyxiation. Laboratory workers have now demonstrated that hyperglycaemia is fairly common. Bradner and Reimann found acetonuria in 61.7 per cent of Deaver's post-operative cases.

The experimental work reported in the past led the writer and most others to believe that when nitrous oxide was not given to the point of cyanosis it carried no danger to mother or foetus. The present study, however, shows conclusively that it is possible to kill the foetus *in utero* by the long-continued administration of nitrous oxide-oxygen even when no microscopic evidences of asphyxia are observed. Furthermore, it is apparent that this danger is not entirely eliminated by supplying oxygen in the percentage found in air.

Several factors probably work together in causing the asphyxiation of the foetus *in utero*. It was demonstrated by Sir Humphrey Davy that nitrous oxide will displace air and oxygen from water. Buxton found that nitrous oxide can "actually oust oxygen from its absorption," and with great rapidity become associated with some of the blood constituents. And more recently it has been demonstrated that any narcotic interferes with normal cell metabolism. Hence it is apparent that when nitrous oxide-oxygen is administered the blood not only contains less than the normal amount of oxygen, but the body cells are less able to utilize the oxygen present. Considering with these facts, the more or less complicated method of supplying oxygen to the foetus *in utero*, it is perfectly logical to assume that the foetus will show greater evidence of asphyxia than the mother.

All experimental work indicates that the dangers from nitrous oxide-oxygen without evident cyanosis, results from the long-continued interference with cell metabolism. Therefore, it is fair to assume that with our very limited intermittent use of nitrous oxide-oxygen during the painful stage of labor there is practically no danger. The nitrous oxide is inhaled only during the first four or six inhalations after the beginning of the contraction and is largely eliminated by the time the uterus relaxes to the point that any appreciable amount could be absorbed into the foetal circulation. Normal metabolism is always possible during the interval between contractions.

CHOICE OF ANAESTHETIC DURING PREGNANCY.—The long-continued administration of any anaesthetic is a source of danger to the foetus. Chloroform, because of its greater toxicity, and nitrous oxide, because of its mechanically interfering with the oxygen supply, are apparently more dangerous to the foetus when continuously administered than ether. Ether is better borne by the very young than chloroform or nitrous oxide. Surgical operations

should be avoided during pregnancy, but when necessary the writer believes that ether is the inhalation anaesthetic of choice.

CHOICE OF ANAESTHETIC IN LABOR.—The danger of each anaesthetic is materially lessened by the intermittent administration in labor, and the small amounts employed. The value of an anaesthetic at this time varies in proportion to the degree of analgesia which may be secured during the first few inhalations after the beginning of a contraction. Chloroform and nitrous oxide, properly administered, afford about equal relief. But chloroform is more toxic, less pleasant, and interferes to a greater degree with the progress of labor. The administration of chloroform with pure oxygen is very expensive and probably does not increase its safety. For the patients who cannot afford nitrous oxide-oxygen the writer uses etherized air, self-administered in the way that nitrous oxide is given. This has many advantages over the old method of using the cone and it is very inexpensive. It must be remembered that babies born after the mothers have had chloroform or ether require many hours to completely eliminate the anaesthetic, and, therefore the writer believes the intermittent use of nitrous oxide-oxygen the safest and most desirable analgesic in labor.

GENERAL CONCLUSIONS.—1. The administration of chloroform, ether, or nitrous oxide-oxygen to pregnant or non-pregnant animals, if given over a long period of time and repeated on successive days causes degenerative changes in the tissues. The changes found in the liver are the most constant. Those following the use of chloroform are the most severe.

2. If the degenaration is not sufficiently great to cause death, the animal gradually recovers from the effect of the anaesthetic, but it seems probable that results of the injury may persist for a considerable time.

3. With ether and nitrous oxide-oxygen the changes are chiefly those of cell asphyxiation, yet it is evident that the cells recover more slowly following ether than they do after nitrous oxide. The central necrosis following chloroform is very different from that seen in asphyxiation and more permanent.

4. The long-continued use of these anaesthetics must be considered dangerous to the foetus *in utero*. Chloroform and nitrous oxide anaesthesia seem more wangerous to the foetus than ether. The continuous nitrous oxide-

oxygen analgesia while less dangerous than the anaesthesia, should not be administered over long periods.

5. The marked fatty degeneration of the livers in all three of the young born after their mothers had only one hour of chloroform-oxygen anaesthesia shows that pure oxygen does not remove the danger of chloroform.

6. The changes following the use of nitrous oxide being identical with those seen after ordinary asphyxiation it seems fair to believe them due to long-continued interference with cell oxidation.

7. There is no reason for believing that the intermittent use of four or six inhalations of nitrous oxide-oxygen at the beginning of the uterine contractions can be of any material danger to the foetus. The nitrous oxide absorbed has been largely eliminated by the end of the contraction and normal metabolism is not disturbed during the interval.

8. Since it is evident that anaesthesia during pregnancy may be a source of considerable danger to the foetus, it is believed that operations should be avoided, if possible, during this period. The foetus *in utero* and the newborn would appear to stand ether anaesthesia better than chloroform or nitrous oxide-oxygen.

Davis's view that nitrous oxide is more dangerous to the foetus *in utero*, especially when used for operations during pregnancy and operative obstetrics, is at variance with the mature opinion of leading anaesthetists. In fact, nitrous oxide-oxygen anaesthesia is finding one of its exceptional fields of usefulness and safety in sparing both the mother and child when surgical operations have to be performed during pregnancy. In discussing Davis's experimental researches before the Fifth Annual Meeting of the American Association of Anaesthetists, John R. Worley, of Dallas, Texas, said: "In reference to the effects of nitrous oxide-oxygen on the foetus *in utero*, I have never known a pregnant woman, coming to operation under this anaesthetic, for some surgical procedure, to abort or miscarry."

The recent work of W. B. Cannon and McKeen Cattell, of the Physiological Laboratory of Harvard Medical School, would indicate that in using nitrous oxide-oxygen anaesthesia during pregnancy it is important from the safety-first viewpoint to give the greatest possible admixture of oxygen consist-

ent with the necessary degree of narcosis. In the presence of such complicating factors as shock, haemorrhage and acidosis, Cannon and Cattell have found that oxygen admixture up to 50 and 60 per cent may be required by the metabolic needs of the patient's peculiar condition. Studies are now under way, under the auspices of the National Anaesthesia Research Society, to determine the optimum oxygen requirement during anaesthesia in the presence of various complicating conditions.

Of course there is greater danger to the foetus of a guinea pig, inhaling nitrous oxide-oxygen for excessive periods, when not in labor, than would obtain by its inhalation during contractions in labor, as used clinically; also it is far more difficult to gauge the oxygen requirement in animal experiments than in operations on the human being and during labor or operative obstetrics. In all events, whether nitrous oxide-oxygen or ether be used for operations during pregnancy or operative obstetrics, it would seem the part of discretion to use a high percentage of oxygenation.

LEVY'S VIEWS ON CHLOROFORM FIBRILLATION AND ITS DANGERS.—Apart from the possibility of late poisoning, chloroform may be the exciting cause of death in the course of anaesthesia. Levy, of London, from his studies states that: "Death from ventricular fibrillation under chloroform may be observed under any of the following and allied conditions: *A—During the induction and early stages of administration;* (1) during struggling and excitement; (2) on removal of the chloroform; (3) on abrupt administration of the chloroform after removal or its sudden increase during a very light period of anaesthesia; and (4) by any combination of these occurrences. *B—During operation by strong sensory stimuli under light anaesthesia. C—After operation on removal of the chloroform, especially after a short operation.*"

As all these conditions are met with in the use of chloroform in labor, due precaution should be exercised at all times.

CHAPTER FOUR
Circulatory Changes

Blood Changes under Anaesthesia and Analgesia ❧ The Decrease of Blood Catalase by Various Anaesthetics ❧ Nitrous Oxide-Oxygen and the Alkali Reserve ❧ Circulatory Disturbances ❧ Further Experimental Studies on the Effects of Anaesthetics in Shock ❧ Blood Pressure Reactions as an Index of the Patient's Resistance, Operative Shock and the Degrees of Circulatory Depression ❧ Relation of Muscular Relaxation to Circulatory Depression and Certain Contra-Indications ❧

IN VIEW OF THE FACT that women in labor present many and varied forms of blood diacrasies, it is important to remember that all anaesthetics cause changes in the blood. Theodore D. Casto, of Philadelphia, in reporting his experimental researches in "Blood Changes under Anaesthesia and Analgesia," before the Academy of Stomatology, the Panama-Pacific Dental Congress and the Third Annual Meeting of the Interstate Anaesthetists, summarized his conclusions as follows:

Blood Changes under Anaesthesia and Analgesia.—"The bibliographic review of this subject, supplemented by experiments on human and animal subjects, would indicate that haemoglobin is always reduced under anaesthesia by chloroform, ether or nitrous oxide-oxygen. Haemoglobin is markedly reduced under ether and the greatest reduction in pigment is at the end of 24 hours, after which there is a gradual return to normal in about 100 hours. Under nitrous oxide-oxygen anaesthesia the reduction is not only slight but the return to normal occurs in from 2 to 3 hours. Any case with a color-index of haemoglobin below 60 per cent should be considered a hazardous risk under ether anaesthesia on account of the rapid reduction of

haemoglobin during the first 20 minutes of etherization. Nitrous oxide-oxygen anaesthesia is indicated in the presence of imperilling anaemia when an operative procedure is imperative. * * *

"There is a polycythaemia during ether anaesthesia and an oligocythaemia under nitrous oxide-oxygen. * * *

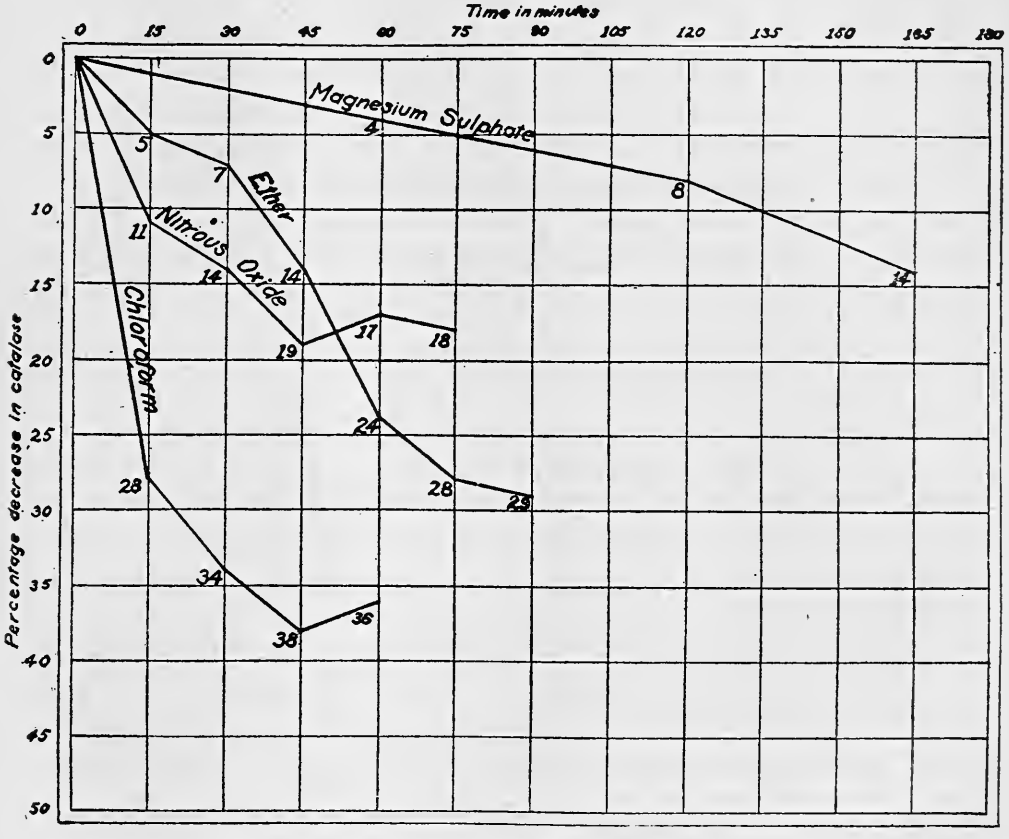
"Haemolysis is observed under chloroform and ether, but no degenerated or crenated cells have been found. * * * Leucocytes have increased, on an average, under all anaesthetic agents. A study of the different varieties showing a marked tendency on the part of the polynuclear neutrophiles to decrease and the lymphocytes to increase. A study of the transitional and eosinophiles showed no changes of special interest, as did segmentation. Erythrocytes are decreased in number after anaesthesia with nitrous oxide-oxygen for 30 minutes to one hour. The ability of erythrocytes to retain their stain is slightly lessened in some instances. * * *

"The acid production of metabolism may be increased under anaesthesia when deep cyanosis is permitted to occur or continue; but when a sufficient supply of oxygen is provided this may be prevented. The hydrogen-ion content is the real constant in interpreting acidosis. The decrease in the alkaline reserve of the blood in animal experiments under nitrous oxide-oxygen anaesthesia is comparable to a mild acidosis in man. In the color of the capillary blood the anaesthetist has a valuable and delicate gauge for determining the amount of oxygen necessary for preventing acid metabolic changes due to deep, imperilling or mild degrees of long continued cyanosis. During cyanosis the haemoglobin of the blood gives up its oxygen to the tissues, and this oxygen is not satisfactorily replaced and consequent reductions in haemoglobin are noted. While nitrous oxide-oxygen may well be considered the least harmful of anaesthetic agents, nevertheless it is quite evident that certain definite blood changes occur under its influence."

Fortunately these are evanescent and can be obviated by proper and skillful administration of analgesia and anaesthesia.

Decrease of Blood Catalase by Various Anaesthetics.—Working in the Physiological Laboratory of the University of Illinois, W. E. Burge, of Urbana, found that whatever increased oxidation in the body produced a corresponding increase in catalase, an enzyme possessing the prop-

erty of liberating oxygen from hydrogen peroxide, by stimulating the liver to an increased output of this enzyme, and that whatever decreased oxidation produced a corresponding decrease in catalase by decreasing the output from the liver, as well as by the direct destruction of the enzyme. Hence, the conclusion was drawn that catalase is the enzyme principally responsible for



Graphic Chart. Showing the Results of Burge's Researches in the Decrease of Catalase under Various Anaesthetics.

oxidation in the body. An investigation was then begun, by Burge, to determine if anaesthetics produced a decrease in the catalase of the blood and of the tissues, parallel with the decrease produced in oxidation, and if this decrease was proportional to the depth of the anaesthesia. The accompanying chart shows the results of Burge's researches graphically.

From his investigations Burge concludes that: "Narcotics of widely different constitution, such as chloroform, ether, nitrous oxide and magnesium sulphate, decrease the catalase of the blood, parallel with the increase in the depth of narcosis. Also that a very powerful anaesthetic, such as chloroform, decreases the catalase more quickly and extensively than does a less powerful anaesthetic, such as ether. A slowly acting anaesthetic, such as magnesium sulphate, decreases the catalase of the blood more slowly than a quickly acting anaesthetic, such as nitrous oxide. It was also found that when the catalase had been decreased as far as it could be by the use of nitrous oxide, it could be decreased considerably more by changing to chloroform or ether. Burge, therefore, concludes that: the greater tendency toward acidosis in chloroform and ether narcosis may be due to this greater destruction of catalase with resulting decrease in oxidation, and to the greater injury of the liver, the organ in which catalase is formed.

Burge's researches have received clinical corroboration in the records of Morris H. Clark, of Kansas City, who has noted a very marked reduction in the incidence of *icterus neonatorum* in babies delivered under nitrous oxide-oxygen analgesia and anaesthesia.

NITROUS OXIDE-OXYGEN AND THE ALKALI RESERVE. — That anaesthesit and operation are accompanied by a reduction in the alkali reserve of the blood has also been shown by Crile and Menten, Austin and Jonas, Morriss, Casto, Cadwell and Cleveland. It is a well known fact that patients with a low alkali reserve withstand operation poorly and may pass from anaesthesia into coma and die. In his investigations of the effects of anaesthesia and operation on existing acidosis in the severely wounded at the Front, W. B. Cannon, of Boston, found that the fall in alkali reserve is likely to be greater the lower the original capacity. Goeffrey Marshall, of London, in his Casualty Clearing Station experiences as an anaesthetist, testifies that anaesthesia with nitrous oxide-oxygen is especially to be recommended in operating on patients in shock, because it leaves the patient in much better condition than do other anaesthetics. Crile and Lower, of Cleveland, also maintain that nitrous oxide-oxygen anaesthesia is less likely to increase acidosis or shock than ether.

It can be readily inferred, therefore, that when women during pregnancy,

in labor or during operative obstetrics, show symptoms of shock or acidosis or have been exsanguinated by haemorrhage, they should, by all means, be given the protection of nitrous oxide-oxygen analgesia and anaesthesia. This contention receives further corroboration from a study of circulatory reactions under various anaesthetics.

Circulatory Disturbances.—Women in labor and submitting to operative obstetrics present many phases of blood pressure and disturbances of the circulatory system. In this connection the following conclusions of McKesson, who has made an exhaustive study of the subject, are pertinent and important:

"None of the general anaesthetics are capable of producing and maintaining increased blood pressure. As has been repeatedly shown the fall in blood pressure, as a result of the anaesthesia, varies with the different agents used; chloroform causing the earliest and most abrupt fall by a reduction in the pulse pressure as well as the diastolic pressure; ether exhibiting a similar action to chloroform, though later in development, and more gradual in its onset. The fall under chloroform is usually noticeable by the end of fifteen minutes and within a few minutes, as pointed out by Fairlie, the low figures due to the direct action of the anaesthetic, are reached, when other factors may still further decrease the pressures. The fall under ether does not usually begin under twenty minutes, when properly administered, but the low figures may not be reached even during the operation, since there is often a tendency for the pressures to fall progressively after the patient has been returned to bed.

"The morphine-hyoscine-nitrous oxide-oxygen combination (without the use of ether) differs widely from either chloroform or ether, and deserves a few words of explanation. It has been erroneously claimed that nitrous oxide-oxygen increases blood pressure; at least this is not true clinically. However, these gases may be administered, in any operation which is comparatively free of other shock-producing factors, for two hours without a material change in either diastolic or systolic pressure, but there is a time-limit beyond which the blood pressures will progressively fall, even under nitrous oxide-oxygen, but differing from ether, this fall is discontinued at once upon removing the anaesthetic and is followed by a comparatively rapid rise, approaching the normal pressures in a few minutes. This data has been obtained by the writer

during prolonged administrations for the relief of gall-stone colic and eclamptic seizures. * * *

"The morphine-hyoscine, which is almost universally used prior to nitrous oxide-oxygen anaesthesia, as well as by some in the first stage of labor, occasionally sets the pressures at from 5 to 15 mm. lower than the patient's normal, which is especially noticeable in patients whose normal pressures are abnormally high for their age; but if administered in proper dosage, this preliminary narcosis is of material assistance in relieving anxiety and the circulatory depression associated with it, as well as further assisting the analgesia or anaesthesia in preventing shock in a severe or prolonged operation. On several occasions it has seemed that the morphine-hyoscine action has prevented a fatal issue after severe shock producing operations."

In the administration of nitrous oxide-oxygen anaesthesia it has been McKesson's custom to use the highest percentages of oxygen consistent with the required degree of surgical narcosis, hence, it is not surprising to find that Cannon's researches, on the effects of anaesthetics on blood pressure in operation on the severely wounded, have led him to the conclusion that: to prevent the imperilling fall of blood pressure in shock nitrous oxide should be given with as much oxygen admixture as possible.

Cannon has also observed that if morphine has been previously given, the amount of nitrous oxide in relation to oxygen can be greatly reduced; and, furthermore, in very bad risks *analgesia* often suffices for any required surgical procedure.

The value of *light* nitrous oxide-oxygen anaesthesia with high percentages of oxygen and proper dosage of morphine was demonstrated at the Front by James T. Gathmey, of New York City, who administered the gases by means of a face inhaler under millimetric pressure and virtually solved the anaesthesia problem in lung surgery in the most desperate cases.

FURTHER EXPERIMENTAL STUDIES ON THE EFFECTS OF ANAESTICS IN SHOCK.—Continuing his researches, McKeen Cattell, speaking during the Sixth Annual Meeting of the American Association of Anaesthetists, reported the main points of his later results in the following summary:

1. In the normal animal, ether, rapidly administered, causes a moderate fall in blood pressure, followed immediately by a recovery, so that by the

time a degree of anaesthetization is reached sufficient to cause a disappearance of the eye reflex, the pressure is normal. In shock the animal becomes very sensitive to ether, the same degree of anaesthesia produced under exactly similar conditions resulting in a marked drop in blood pressure.

2. An increased sensitiveness to ether is brought about by any circumstances which tend to depress the general condition of the animal such as low blood pressure, haemorrhage, severe operation, or the injection of acid into the circulation.

3. *In a shocked animal, sensitive to ether, nitrous oxide and oxygen may be given in the most favorable proportions, so as to produce the same degree of anaesthesia produced by ether without causing a fall in blood pressure.*

4. Experiments on the heart volume in intact cats, and on contractions of the isolated turtle heart, together with deductions from blood pressure, show that ether, from the very beginning of its administration, results in a depression of the heart and a decrease in its output, which is sufficient to account for the fall in pressure in both the normal and the shocked animal.

5. Large doses of adrenalin injected intravenously in shocked animals usually results in the disappearance of the sensitiveness to ether for a period of an hour or more. The evidence indicates that adrenalin acts on the heart in a manner which antagonizes the effects of ether. Pituitrin does not influence the pressure drop produced by ether in the shocked animal.

6. Determinations of leg volume with a plethysmograph, perfusion experiments, and results obtained from the injection of ether directly into the circulation, together with the form of the blood pressure curves, indicate that ether causes a contraction of the peripheral vessels in the normal animal. This contraction is caused (a) by a direct stimulation of the vasomotor center and (b) by a reflex to the fall in pressure resulting from depression of the heart. In shock no evidence of a vaso-constriction produced by ether was obtained, and pressor effects from asphyxia or sensory nerve stimulation become less or are entirely absent.

7. The cause of the greater depressing influence of ether on the blood pressure in shock, is a disturbance of the vasomotor system. The usual compensatory constriction no longer occurs to offset the decreased output of the heart, so that there is no recovery of the blood pressure during the inhalation

of ether, but instead, the pressure continues to fall. This might be due to a depression of the vasomotor center or to an already existing maximum constriction, so that there would be no compensation.

Blood Pressure Reactions as an Index of the Patient's Resistance, Operative Shock and the Degrees of Circulatory Depression.—In presenting the value of "Blood Pressure Guides in Operation and Surgical Prognosis," to the Boston Academy of Medicine, A. H. Miller, of Providence, R. I., emphasized the value of Moots's Rule for determining the index of the patient's resistance. This rule may be thus stated:

"The pressure ratio, a fraction having the pulse pressure as numerator and the diastolic pressure as denominator, may be normal between 40 and 60 per cent. If the ratio is either high or low, there is reason to apprehend danger. If the ratio lies between 25 and 75 per cent the case is probably operable; if outside these limits, it is probably inoperable."

In checking up the accuracy of this rule in a series of 1,000 cases, Miller found that in the operable risks 3.23 per cent of the patients died and 96.77 per cent recovered; in the inoperable risks 23.07 per cent of the patients died and 76.93 per cent recovered.

For determining the presence of operative shock under anaesthesia McKesson's Rule is an important guide. It is thus stated:

"With a pulse rate of 120 or more, a pulse pressure of 20 mm. or less, and a diastolic pressure of 80 mm. or less in a patient, who, at the beginning of the operation, had presented normal pressures, frank shock has occurred. If these low pressures are continued without improvement for more than half an hour, a vicious circle is generally established, which, without treatment, will cause the death of a patient."

In checking up the accuracy of this rule in the 1,000 cases studied, Miller found that in patients, who were within the danger zone as determined by this rule for more than 25 minutes, the mortality rate was 69.23 per cent.

In order to standardize the surgeon's and anaesthetist's conception of circulatory depression, the following three degrees, established by Moots and McKesson, have been accepted by the National Anaesthesia Research Society and included in their uniform Anaesthesia Record.

These degrees of circulatory depression are:

1. Safe: Ten to 15 per cent increase in pulse rate without change in pressure. Ten to 15 per cent decrease in blood pressure without change in pulse rate.

2. Dangerous: Fifteen to 25 per cent increase in pulse rate with 15 to 25 per cent decrease in blood pressure.

3. Fatal: Progressively increasing pulse rate above 100 with progressively falling blood pressure of 80 mm. or less systolic, and 20 mm. or less pulse pressure, for more than 20 minutes.

Relation of Muscular Relaxation to Circulatory Depression.—Moots and McKesson, speaking before the Joint Meeting of the American Association of Gynecologists and Obstetricians and Interstate Anaesthetists, 1919, emphasized the fact that: "It is not remarkable that nitrous oxide-oxygen should be safer in shock and in preventing shock, than other anaesthetics, when one recalls that muscle cannot be paralyzed with it. The greatest responsibility of the anaesthetist is to avoid relative over-dosing of the patient in an effort to secure flabby musculature at the demand of the surgeon or specialist. The relaxation is not confined to striated muscles of the abdomen and extremities, but extends to the striated muscle of the heart. The effect is at once reflected by the pulse pressure and, if pushed too far, the diastolic pressure is also decreased, showing the action upon smooth muscle as well. The clinical study of blood pressure has convinced us that the final factor in shock is muscular exhaustion or an interference with muscular action. One thing is most apparent: the average patient, having been profoundly anaesthetized for extreme relaxation, is half shocked—a second degree depression—and it often takes but little trauma to complete the picture of third degree depression."

Before proceeding further, it would seem advisable to dwell for a moment on the contra-indications to nitrous oxide-oxygen anaesthesia, as given by Sajous, as they pertain especially to conditions of the circulatory and respiratory systems, which materially effect blood pressure.

Contra-Indications. — "Circulatory abnormalities," writes Sajous, "constitute the most frequent contra-indications to nitrous oxide, which is to be

avoided both in well marked atheroma, especially if a high blood pressure co-exists, and in cardiac dilatation, with or without a valvular lesion. Mitral stenosis, aortic regurgitation and *beer heart* are generally held to contra-indicate nitrous oxide, as does also the combination of high blood pressure with a weak cardiac first sound. * * * *

"Buxton regards the anaemic individual, the *overgrown* boy, the nervous, sensitive child subject to fainting; the child with congenital cyanosis and the person with an hypertrophied heart among the most dangerous types of individuals for nitrous oxide, syncope and asphyxia easily occurring in these cases. *With care to obviate struggling and undue exclusion of air or oxygen, however, no absolute contra-indication to nitrous oxide anaesthesia is present even in these cases.* * * * *

"Marked respiratory embarrassment, especially if due to a swelling which will be made worse through venous engorgement, contra-indicates nitrous oxide-anaesthesia, but if the dyspnoea be of minor extent, as is frequently the case in patients with tonsillar swelling, Ludwig's angina, glandular and other enlargements exerting pressure on the respiratory channels, enlarged thymus, large adenoid growths, intra-abdominal effusions, or growths pressing on the diaphragm or heart, obesity, pleural adhesions and general affections causing dyspnoea, nitrous oxide may be used, provided great care is taken to avoid all asphyxia during anaesthesia. * * * *

"In the aged, intolerance of asphyxia and circulatory stress is likewise a feature to be remembered, especially if chronic bronchitis is present; nitrous oxide is not, however, contra-indicated by old age *per se.* In pregnant women it should be borne in mind that excessive exclusion of air may injure the foetus or bring on labor."

CHAPTER FIVE
Obstetrical Analgesia

Essentials of Ideal Obstetrical Analgesia ❧ Fundamental Considerations ❧ Effects of Analgesia on the Special Senses ❧ Guiding Signs During Intermittent and Continuous Analgesia. Various Mixtures of Nitrous Oxide, Air and Oxygen ❧ Pointers in the Administration of Obstetrical Analgesia ❧ The Method of Self-Administration and Co-operation of the Patient ❧ Controlling the Depth and Speed of Analgesia ❧ Charting the Varied Methods of Analgesia ❧ Anticipating Uterine Contraction ❧ Lapses into Anaesthesia During Continuous Analgesia ❧ Some Devices for Facilitating the Administration of Analgesia ❧

NO ONE ANY LONGER BELIEVES that labor pains do not hurt. The problem has been to find a method of relief that meets the peculiar requirements of normal labor and operative obstetrics. In the former, analgesia must provide for the intermittent pain and the comfortable interval; the holding of the breath and normal breathing; the physical relief of pain without eliminating the patient's reasonable and conscious co-operation, making it unnecessary to have a corps of trained assistants and especially prepared rooms. It must be a method which can be used safely and successfully by the physician *alone*, when necessary or with inexpert help in emergencies. In the latter, the matter of anaesthesia must be safe for both the mother and the child, irrespective of the hazard of the case and the operative procedure necessitated.

Nitrous oxide-oxygen analgesia and anaesthesia meet all the requirements of normal labor and operative obstetrics in practically an ideal manner.

The present vogue of nitrous oxide in obstetrics, according to C. E. Turner, of Columbus, O., may be accounted for, in great measure, because it

provides: (1) A shorter second stage of labor that is practically painless. (2) Complete relaxation of the soft parts which minimizes the danger of tears. (3) A total absence of restlessness and rigidity. (4) The absence of exhaustion. (5) The rapid return to normal after analgesia, and (6) *Better Babies.* Any unhappy end-results are usually the fault of unskilled use.

Nitrous oxide-oxygen relaxes the muscular structures to a degree comparable to normal sleep, in the experience of Turner. The nerve centers presiding over the five physical senses are affected, one at a time, in recognized and constant sequence. Analgesia begins with the suppression of the centers of feeling, but the patient remains susceptible to suggestions long after the sense of touch has been obtunded, and because of this the patient will co-operate throughout labor even under analgesia.

FUNDAMENTAL CONSIDERATIONS: EFFECTS OF ANALGESIA ON THE SPECIAL SENSES.—Before proceeding to a discussion of the technique of analgesia it would seem advisable to emphasize some of its fundamental considerations.

There are slight differences in the sensations resulting from analgesia in different individuals, but a detailed analysis by McMechan, compiled from various sources, shows that the more common sensations are about as follows:

"Shortly after the beginning of induction of analgesia the anaesthetic can be *tasted*, and a little later it can be *smelled;* after which the patient begins to *feel* its effects. Barber, of Chicago, has encountered patients so susceptible to nitrous oxide that analgesia supervened synchronously with the *tasting* of the gas. * * *

"The first unusual sensation is one of *warmth* throughout the body, followed by a sensation of *speed*, undoubtedly due to acceleration of the pulse and a slight rise in blood pressure due to oxygen limitation. The voice takes on a guttural sound and the patient experiences a *thick, large feeling*, the result of slight engorgement of the superficial blood vessels, followed by *an exaggeration of all sounds, an increase in the apparent distance of objects, a spinning or swinging sensation and tingling in the skin*, usually associated with the appearance of perspiration in the palms of the hands or on the forehead, especially in stout subjects. Immediately after a *general numbness, apathy, slight incoordination and tired feeling develop, while the sensations of sound and touch*

become somewhat dulled and vision blurred. Remarkable as it may seem, a clear line of demarkation usually separates the realization of outside impressions, such as surroundings and pain from reasoning ability, throughout analgesia. Mental aberration of any extent, only occurs if the stage of excitement is allowed to develop, although momentary aberration may be noticeable when the analgesia is discontinued, (especially if it has been continuous), and all mental processes and special senses reestablish themselves with *confusing rapidity.*"

The state of *analgesia* is made possible by the fact that in the development of general anaesthesia with nitrous oxide the *first special sense to surrender is the sense of pain, leaving the other special senses less influenced.*

GUIDING SIGNS DURING INTERMITTENT AND CONTINUOUS ANALGESIA.—Impairment of the sense of direction or location is a reliable guide to the onset of analgesia. Thus in the self-administration method, the hand of the parturient woman holding the inhaler will falter in keeping it in place. The eye, however, is a more accurate indicator of the depth of analgesia. Normally, under analgesia, the eyelids should wink lazily and vision should be slightly blurred. This blurring has been utilized by Lynch and other obstetricians as a guide to the patient during self-administration in conjunction with a light fixed in a certain position for the purpose. As analgesia deepens the eyeball will rotate from side to side. *Pain will be noted in a slight twinge of the eye more quickly than by any other sign.* On the contrary, especially during continuous analgesia or with an over-dose in intermittent analgesia, if the winking becomes sluggish or the lids remain closed the patient is going to sleep. Occasionally the eyes will become set and the patient stare fixedly ahead. This is a premonitory sign of the onset of a stage of excitement and must immediately be remedied by decreasing the flow of the gases.

No stage of analgesia is satisfactory unless the patient is indifferent to everything except the explicit directions of the obstetrician for co-operation and assists by bearing down during the pain. The fearful, neurotic or hysterical cannot be handled under intermittent analgesia; continuous analgesia must be administered to such, and some can only be handled under anaesthesia. Hilarity on the one hand and excitement or lapsing consciousness on the other indicate the extremes of analgesia. The former is due to too much admixture of

air or oxygen, the latter to pushing the anaesthetic; although, as Guedel points out, continuous analgesia is prone to lapse into anaesthesia on account of an accumulative effect of the nitrous oxide in the system and imperfect elimination after a certain length of time.

In its last analysis the technique of nitrous oxide analgesia consists in diluting the gas with enough air or oxygen to prevent the loss of consciousness and yet securing sufficient nitrous oxide saturation for the relief of the pain.

Various Mixtures of Nitrous Oxide, Air and Oxygen.—Different as the techniques of various authorities may seem, there is a fundamental similarity. The following are some of the methods in vogue:

1. Pure nitrous oxide, or nitrous oxide with 10 to 15 per cent air, the dose being regulated by the number of inspirations, from 3 to 6 or more at the onset of each pain.

2. Pure nitrous oxide for the first 2 or 3 inspirations, diluting the fourth and fifth with 2 per cent oxygen, and subsequent inspirations with 20 to 30 per cent oxygen at the onset of each pain.

3. The employment of set mixtures without changing during any single pain administration: (a) nitrous oxide 80 per cent, oxygen 5, and the balance air; (b) nitrous oxide with 2 or 3 per cent oxygen; (c) nitrous oxide with 5 to 15 per cent air, and (d) nitrous oxide 30 to 80 gallons per hour (sight-feed measurement) and oxygen 10 to 30 gallons, with the balance air.

For *intermittent, single pain analgesia*, McKesson prefers the following technique of administration:

1. Turn on nitrous oxide.
2. Set air mixer at 10 per cent (two holes), or oxygen at 5 per cent.
3. With the onset of each uterine contraction apply the inhaler and instruct the patient to take three quick deep inhalations, holding the last one in the lungs as long as possible, after removal of the inhaler.
4. Patient breathes air between pains and a similar administration is made synchronously with the onset of each pain.

Pointers in the Administration of Obstetrical Analgesia.—For the successful administration of nitrous oxide-oxygen analgesia a few de-

tails, emphasized by Davis, must be carefully observed: (1) The patient should be assured that when the pains become severe they can be relieved. This tends to remove fear and lessens the possibilities of excitement or hysteria. (2) When first administering the nitrous oxide give enough to cause a deep analgesia or even a light anaesthesia. This gives the patient confidence in its ability to relieve pain. (3) Determine the number of inhalations necessary to relieve pain and increase by one or more as the uterine contractions become more severe. (4) The patient must breathe the gas mixture with the first suggestion of an approaching contraction, since she must absorb enough nitrous oxide to produce analgesia before the height or painful stage of the contraction. If she experiences the sensation of pain she is carried through the contraction without amnesia and in many instances with her memory of the pain highly intensified. This same rule applies to all manipulations or operations under nitrous oxide-oxygen analgesia or anaesthesia, and explains many of the failures reported. Nitrous oxide-oxygen cannot be given according to ether rules. Obstetrical analgesia can be administered successfully by an understanding of both the obstetrical and anaesthetic problems involved. Trained anaesthetists usually fail through ignorance of the mechanism of labor while obstetricians fail on account of their ignorance of the anaesthetic and its correct method of use. (5) A complete anaesthesia or a continuous analgesia may be necessary for a few minutes, but it should be discontinued as soon as the acute pain has been controlled.

The Method of Self-Administration and Co-operation of the Patient.—With a co-operating patient the self-administration method may be safely and efficiently utilized toward the close of the first stage of labor and almost entirely throughout the second stage. Guedel maintains that self-administration is peculiarly serviceable in this that it gives the child-bearing woman something to distract her attention. The method is entirely safe and without danger of untoward accident, for if the patient inhales sufficient nitrous oxide to lapse into narcosis her hand, holding the inhaler, relaxes and falls to her side, thus discontinuing the administration. Satisfactory self-administration necessitates not only a co-operating patient but a thorough understanding in the mind of such a patient of what constitutes analgesia. It is important for the obstetrician or anaesthetist to explain how a given number of inhalations of the mixture of gases will obtund the pain, and to emphasize that an excess

of the anaesthetic only complicates analgesia and increases its cost. Patients should also be instructed *only to bear down* on advice of the obstetrician. Nitrous oxide analgesia stimulates uterine contractions, and it is no uncommon occurrence in relatively easy births, for the parturient woman under analgesia to precipitate without realizing that the baby is being born. Also in securing the absolute co-operation of the patient in the earlier part of labor, the physician is able to control her voluntary efforts toward its close, when it is important to allow the perineum to distend gradually to prevent internal or external lacerations. It should be remembered, too, that under analgesia the progress of labor cannot be judged by the patient's complaints, and consequently occasional rectal examinations should be made to determine the position of the child.

Self-administration under proper supervision, by a sensible mother, is less dangerous, so far as over-dosage, cyanosis and lapses into unconsciousness are concerned, than when the inhaler is handled by some lay attendant. With the skilled obstetrician and the expert anaesthetist controlling the inhaler and apparatus, it is obvious that analgesia will depend entirely on their skill and judgment.

Allen prefers to accomplish analgesia by giving the mixture of the gases during the interval between pains and discontinuing administration during the contractions, at which time it is somewhat difficult for the parturient woman to inhale the analgesic properly.

CONTROLLING THE DEPTH AND SPEED OF ANALGESIA.—The number of inhalations taken at the beginning of each pain determines the *depth* of analgesia, while the amount of air admixture regulates the *speed* of analgesia. Analgesia develops in the shortest time when pure nitrous oxide is inhaled and is progressively slower with increasing dilution. Air is not used, as might be supposed, for the oxygen it contains, since patients, (except those with uncompensated heart lesions, dyspnoea, cyanosis or oedema), do not need oxygen, because they hold their breath during contractions normally. Uncompensated heart lesion cases sometimes have a cyanosis which has persisted for some time, but this can be cleared up by using oxygen instead of air, and such patients may be safely handled, obstetrically, with nitrous oxide-oxygen analgesia carefully given.

CHARTING THE VARIED METHODS OF ANALGESIA.—The object in *intermittent, single pain analgesia* is to secure analgesia ahead of the pain, to maintain it at a depth corresponding to the severity of the pain throughout the entire uterine contraction and to eliminate all nitrous oxide immediately after the cessation of pain, leaving the patient to breathe air during the interval. The manner in which analgesia covers the pain in the usual case is shown in Chart 1.

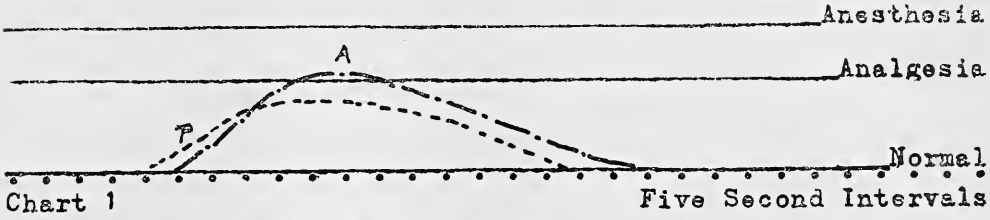


Chart 1. Illustrates the manner in which each labor pain is covered by analgesia in the usual case. P represents the pain curve and A the analgesia curve.

Certain other factors influence the rapidity of induction, (a) the actual respiratory capacity determining the alveolar absorption area, (b) the tidal volume of respiration affecting the elimination of the residual air content and (c) rebreathing. Refractory patients may manifest anoxaemia before the onset of analgesia with pure nitrous oxide, whereas susceptible subjects,—the usual type—will show no manifestation of oxygen deprivation.

If adequate analgesia cannot be secured rapidly enough to completely abolish pain, then the *intermittent* administration should be abandoned for *continuous analgesia.* Guedel has charted the latitude of available analgesia

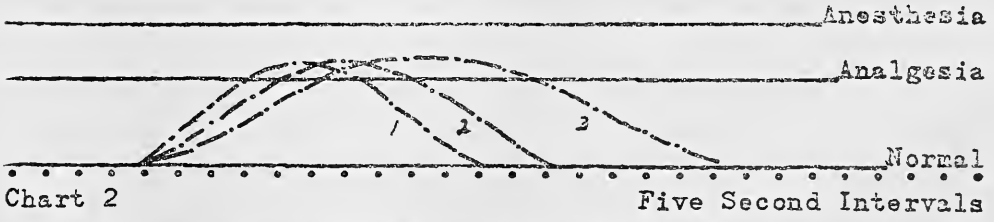


Chart 2. Illustrates different types of analgesia obtained by a single application, withdrawing the inhaler at total analgesia. (1) nitrous oxide 100 per cent; (2) nitrous oxide with 2 per cent oxygen or 6 per cent air; (3) nitrous oxide with approximately 5 per cent oxygen or 10 to 15 per cent air.

with intermittent application of various combinations of nitrous oxide, air and oxygen in Chart 2. An intensive study of this phase of the subject will enable the obstetrician accurately to adapt his mixture to the duration, severity and

frequency of the labor pains and the refractiveness or susceptibility of the various types of patients. In obstetrical practice it is rare to find a patient so refractory that analgesia cannot be successfully and satisfactorily administered. Clinical observations would indicate that 85 to 90 per cent nitrous oxide with 10 to 15 per cent air, or 98 per cent nitrous oxide and 2 per cent oxygen, is productive of the quieter, longer and more satisfactory analgesia with induction of ample rapidity. Occasionally 5 to 7 per cent oxygen and proportionate amounts of nitrous oxide are required.

It usually takes two or three pains before the patient learns that it is important to start promptly, to breathe deeply and quickly and to bear down while holding the last breath to assist labor. She should be told these things to get her co-operation and voluntary assistance, explaining that by holding the breath analgesia is *prolonged*, by bearing down it is *intensified* and assists in the progress of labor, and that talking or breathing during *pain*, after completing the inhalation of the mixture, *disperses analgesia* rapidly and prevents the relief sought. Allen also points out that if an analgesia is attempted during the pain breathing is irregular and voluntary efforts interfere with the proper consumption of the gases.

ANTICIPATING UTERINE CONTRACTION.—The patient usually knows when the contraction begins for some seconds before it hurts. If she is unable

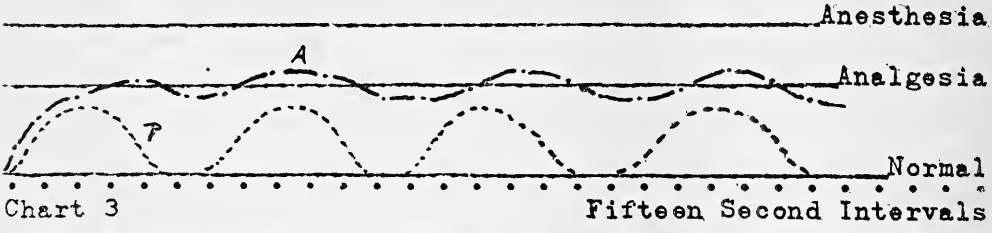


Chart 3. Illustrates the manner in which continuous analgesia covers frequent labor pains. P, pain curve; A, analgesia curve.

to detect the onset of contraction herself, a few seconds before pain is caused, then the obstetrician or anaesthetist must time the administration by feeling for the uterine reflex through the abdominal wall. In forceful contraction with delayed anticipation of pain the air mixer is closed and maximum analgesia speed is sought for and obtained. If, however, the uterine contraction is slow in development then the analgesia should be *slowed* by increasing the air admixture and also if necessary, increasing the number of inhalations. Again,

toward the close of the second stage of labor, if the pains are very close together or almost continuous, analgesia may be made continuous also by alternating a breath or two of nitrous oxide and a breath or so of air. The manner

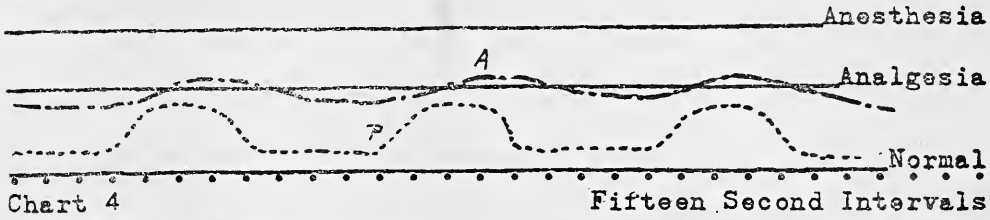


Chart 4. Illustrates the advantage of continuous analgesia in case of interval pain, due as a rule to pressure of the child on neighboring nerves. P, pain curve; A, analgesia curve.

in which this is accomplished has also been charted by Guedel in Charts 3 and 4.

Occasionally the pains are so rapid and severe or the intervals are so painful on account of the child's pressure on pelvic nerves, that even the most complacent and co-operative parturient woman cannot be controlled except under *continuous analgesia.* The mixture given depends on the degree of analgesia necessary to overcome the manifest suffering of the patient, and may vary from nitrous oxide with 30 to 70 per cent air to nitrous oxide with from 15 to 30 per cent oxygen.

Lapses into Anaesthesia During Continuous Analgesia.—The tendency toward lapses into unconsciousness during continuous analgesia may be routinely observed and may occasionally be used to advantage in patients who complain that analgesia is not sufficient to relieve their pain. *It is peculiar that with the return from a lapse into narcosis, the depth of analgesia from the same mixture is increased.* These phases of analgesia have again been charted by Guedel in Charts 5 and 6.

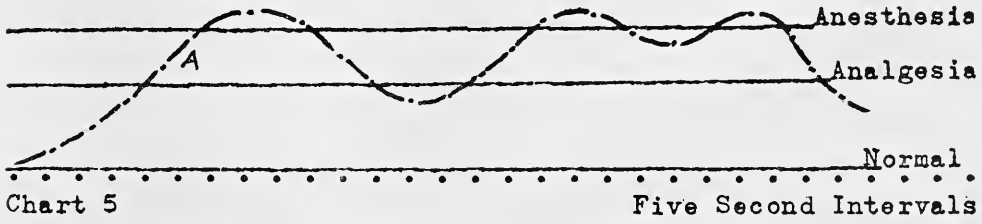


Chart 5. Continuous analgesia curve with self-administration, showing lapses into unconsciousness. A, analgesia curve.

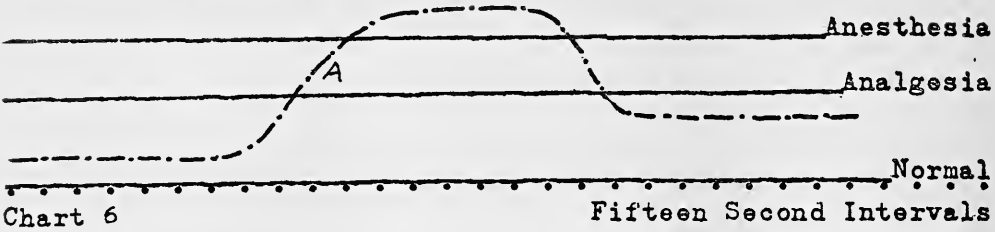


Chart 6. Illustrates an apparent increased depth with the same mixture following a few moments of anaesthesia. A, analgesia curve.

When continuous analgesia is used over a long period of time there is an apparent, progressive increase in depth, with the same mixture, and a tendency to establish a continuous anaesthesia, rather than a deep analgesia as shown in Chart 7.

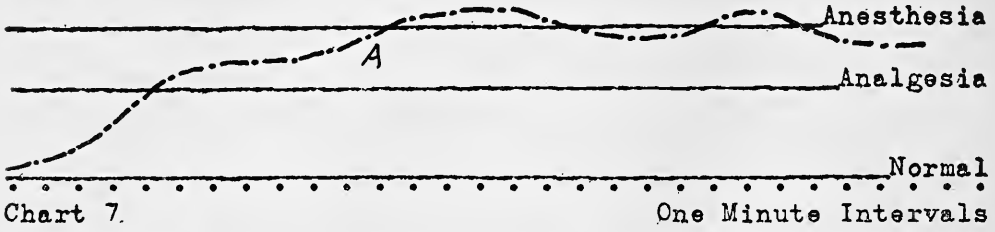


Chart 7. Illustrates an apparent, progressive increase in depth, with the same mixture of gases, continued over a long period of time.

Before concluding this diagramatic consideration of the subject Guedel has also emphasized the fact that when adjuvants are used in conjunction with analgesia, that morphine-hyoscine and other narcotic combinations depress pain perception and may interfere with the timely application of the gas in intermittent analgesia as shown in Chart 8.

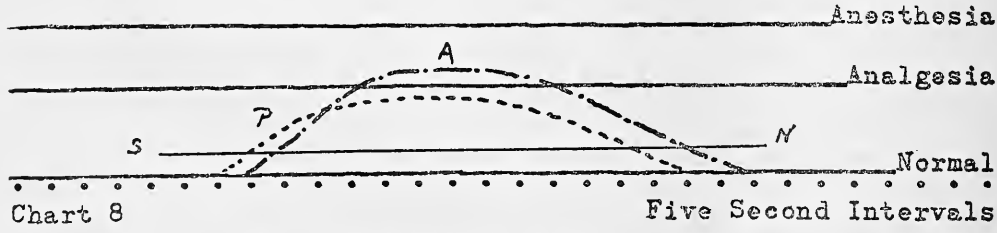


Chart 8. Illustrates how the use of morphine-hyoscine depresses pain perception and interferes with the timely application of the analgesic.

At the last pain of the second stage it is common practice to induce *anaesthesia*, especially if there is any danger of laceration. This may be ac-

complished by holding the mask until 12 to 20 breaths of the mixture of nitrous oxide and oxygen are taken and then delivering while the patient sleeps for 40 to 50 seconds. McKesson adds this perfecting detail: The moment the presenting part is delivered, administer 10 to 20 breaths of pure oxygen, or at least a mixture with 50 per cent oxygen, while the umbilical cord still pulsates. *Intermittent anaesthesia during the course of labor is mentioned only to be condemned.*

Devices for Facilitating the Administration of Analgesia.—In administering nitrous oxide for the relief of pain in labor some obstetricians and anaesthetists prefer the use of the nasal inhaler, some a face mask, while others utilize the one or other according to the type of patients, the stage of labor and the form of analgesia. Allen prefers the use of the nasal inhaler as a routine, in the absence of nasal obstruction, because patients have much less fear of analgesia thus given; they do not suffer from a sense of suffocation and always feel that they are able to talk. Nasal inhalers are now obtainable with check-valves to control the flow of gases, while the automats of several obstetrical devices for analgesia and anaesthesia only permit the flow of the gases during inhalation. Such automatic adjuncts facilitate technique and are also conspicuous sources of economy.

While some administrators are successful in maintaining continuous analgesia with the nasal inhaler, the majority prefer the use of the face mask, as it avoids dilution of the analgesic mixture delivered by mouth breathing, which, under certain circumstances, it is difficult for the woman in labor to control. John H. Evans, of Buffalo, has found it entirely practicable to maintain *continuous analgesia*, sometimes with and frequently without the aid of local anaesthesia, during many major gynecological and obstetrical operations, by the use of the face mask. When occasion demands the face mask will very materially assist in securing the desired speed and depth of analgesia or in maintaining continuous analgesia. It should be remembered that in the presence of nasal obstruction it is difficult and at times almost impossible to obtain any desirable degree of analgesia without giving the gases orally as well as through the nose.

ITROUS OXIDE IS THE IDEAL AGENT FOR THE RELIEF OF PAIN IN LABOR, BECAUSE IT IS INHALED LIKE AIR, IS PRACTICALLY ODORLESS, ALMOST INSTANTANEOUS IN ITS ACTION ON THE PATIENT, AND IS ELIMINATED SO QUICKLY THAT THE GAS HAS LEFT THE BODY BY THE TIME THE NEXT PAIN IS DUE ❧ IT IS DIFFICULT TO CONCEIVE OF AN AGENT WHICH CAN BE USED TO TREAT EACH INDIVIDUAL PAIN, SO THAT AT ANY MOMENT OF LABOR, WHEN MORE SUFFERING OCCURS, A GREATER DOSAGE OF THE ANALGESIC CAN BE INSTANTLY ADMINISTERED, OR WITH LESS PAIN IT MAY BE REDUCED AT ONCE ❧ YET THIS IS PRECISELY WHAT CAN BE DONE WITH NITROUS OXIDE ❧

—E. I. McKesson.

CHAPTER SIX
Obstetrical Anaesthesia

Nitrous Oxide-Oxygen Obstetrical Anaesthesia ❧ The Guiding Signs and Symptoms for Light, Normal and Profound Anaesthesia ❧ Technique of Administration ❧ The Zones of Analgesia and Anaesthesia without Supplemental Narcosis ❧ The Question of Rebreathing ❧ Fractional Rebreathing and its Practical Application ❧ Effects ❧ Opinions on Rebreathing in Obstetrical Analgesia and Anaesthesia ❧ Its Evaluation ❧

WHILE NORMAL LABOR and many obstetrical operaitons can be conducted under intermittent or continuous analgesia or light anaesthesia, some procedures absolutely require complete surgical narcosis. Consequently it would seem advisable to enlarge on the technique of nitrous oxide-oxygen anaesthesia, before proceeding further.

Nitrous Oxide-Oxygen Obstetrical Anaesthesia.—*In its last analysis successful nitrous oxide-oxygen obstetrical anaesthesia depends on the administration of such a proportionate mixture of the gases as will effect complete anaesthesia and sufficient relaxation, without untoward complications.*

There are a few elements in the administration of nitrous oxide-oxygen anaesthesia, which are of such fundamental importance that uniform success cannot be obtained without their guidance.

The condition of the patient as to the state of anaesthesia is controlled entirely by the mixture administered, while the reactions of the patient to various percentage mixtures guides the anaesthetist in securing the plane of anaesthesia required for the contemplated operation. All operations do not require the same depth of anaesthesia nor do all patients react similarly to the same percentages of gases.

When a patient is in a state of normal anaesthesia there is no response to trauma. If such a state is maintained by a given percentage mixture of the gases, then deviation, one way or another, of even 1 per cent of oxygen in the mixture will produce corresponding signs in the patient, so exact are the demands of the human body to gaseous interchange and so delicate its reactions to potent influences. Consequently the requirements of individuals must be met by adjusting anaesthesia to the reactions of pulse and respiration.

Guiding Signs and Symptoms of Light, Normal and Profound Anaesthesia.—McKesson has rather thoroughly worked out the symptomatology of the various planes of nitrous oxide-oxygen anaesthesia. For the sake of classification the guiding signs and symptoms of anaesthesia may be divided into four groups: (1) respiratory changes; (2) eye reflexes; (3) general muscular manifestations; and (4) degree of oxygenation as shown in the color of the lips, nails or skin.

It cannot be too strongly urged that in determining whether to increase or decrease the oxygen percentage in the mixture *all signs* must be considered. To follow color as a guide, practically to the exclusion of all other signs, will prove not only misleading and unsafe but will result in repeated failures, because the anaemic or toxic patient very often will not exhibit changes in color until all other signs would indicate profound anaesthesia, and then, as Cotton and Boothby, of Boston, have pointed out, such a patient may develop an *ashen gray color*, far different from what constitutes the common acceptation of a cyanotic reaction. On the other hand a full blooded or muscular patient will show some cyanosis before anaesthesia is really established. Similarly the causative factor of muscular rigidity must be differentiated.

For ready comparison McKesson has arranged the accompanying chart of the various reactions under *light, normal and profound* anaesthesia.

Indications for More Oxygen.—A preponderance of the available signs establishes the actual plane of anaesthesia as reliably as it can be determined. Regardless of all other signs there are two invariable indications for more oxygen, (1) a widely dilated, irregular, fixed pupil and (2) cessation of respiration. In either case oxygen should be instantaneously forced into the lungs, *once*, *twice* or *three times*, depending upon the reaction or contraction

McKESSON'S NITROUS OXIDE-OXYGEN SIGN CHART

Copyright

LIGHT ANESTHESIA	NORMAL ANESTHESIA	PROFOUND ANESTHESIA
Due to too much oxygen in the mixutre.	Due to a properly balanced mixture of nitrous oxide-oxygen.	Due to too much nitrous oxide in the mixture or to partial obstruction of respiratory passages.
RESPIRATION (a) Superficial slow breathing usually regular. (b) Prolonged inspiration. (c) Phonation due to reflexes or pain. (d) Holding breath, grunting.	**RESPIRATION** (a) Full "machine like" respirations. Regular and faster than normal. (b) Inspiration and expiration nearly equal. (c) No phonation. (d) Continuous uninterrupted respiration.	**RESPIRATION** (a) Irregular rhythm (sobby) usually slower than normal. Spasmodic. (b) Prolonged expiration. (c) Phonation due to muscular spasm of vocal cords. Often crowing. (d) Cessation of respiration from spasm of muscles of exhalation.
MUSCULAR PHENOMENA (a) Movements of rigid muscles. (b) Facial expression of pain or consciousness. (c) Nausea, very rarely. (d) Reflex, or voluntary resistance.	**MUSCULAR PHENOMENA** (a) Immobile and relaxed, but having normal muscular tonus. (b) Expression of normal sleep. (c) Quiet. (d) Quiet. Relaxed.	**MUSCULAR PHENOMENA** (a) Clonic movements, twitching or jerking in early minutes of induction, often start in upper eyelids. (b) Expression wild looking. (c) Swallowing, retching or vomiting, common. (d) Tetanic, spasm, marked rigidity — opisthotonus in some cases.
THE EYE (a) Pupils large, contract to light actively. (b) Conjunctiva sensitive. (c) Eyeballs roll. (d) Eyelids resist opening, wink when touched.	**THE EYE** (a) Pupils small or medium fixed. (b) Conjunctiva insensitive to touch. (c) Eyeballs fixed or slowly roll. (d) Lids often slightly open, relaxed, no winking.	**THE EYE** (a) Pupils fixed, enlarge progressively and finally become irregular in shape. (b) Conjunctiva insensitive. (c) Eyeballs fixed in some position or jerk. (d) Eyelids stiff. Often wide open.
COLOR IN SKIN (a) Pink or no change normally. (b) In anaemics, no color change. (c) In plethorics, slight cyanosis.	**COLOR IN SKIN** (a) Varies from pink to decided cyanotic tint. (b) In anaemics, no color change. (c) In plethorics, considerable cyanosis.	**COLOR IN SKIN** (a) Usually cyanotic. (b) In anaemics, slight flushing, rarely cyanosis. (c) In plethorics, almost black.
REMEDY Decrease the percentage of oxygen in the mixture.		**REMEDY** Increase oxygen in the mixture or in (d) inflate lungs with pure oxygen 1 to 3 times.

of the pupils and the returning pink color following the first or second insufflation. If respirations have ceased they will not begin until 10 to 20 seconds after insufflation, or until the excess of oxygen contained in the lungs shall have been absorbed. But the effect on the color-index, the eye and other reflexes will become apparent in about 7 seconds after the first insufflation.

The Normal Plane of Anaesthesia. — There is a desirable or normal plane of anaesthesia obtainable in every patient, but it may be difficult to establish in some patients if not properly saturated with the anaesthetic at the start, or when the proportions of the gases in the mixture fluctuate widely, intentionally or unintentionally, during the administration. Nitrous oxide-oxygen anaesthesia in major surgery, where relaxation is required, is a technique for the expert anaesthetist. With increased experience, fewer will be the patients who cannot be satisfactorily anaesthetized without supplemental etherization. Surgical relaxation is a condition which is not only unnecessary in obstetrical operations, but is to be positively avoided in these cases.

Technique of Administration. — Anaesthesia is produced as follows with the obstetrical apparatus: (1) Close the air mixer; (2) give pure nitrous oxide until the patient is anaesthetized; requiring 12 to 20 breaths. Remove inhaler if *momentary anaesthesia only* is desired, but (3) if anaesthesia is to be maintained for more than a minute, oxygen is now administered with the nitrous oxide by slightly opening the oxygen tank valve and letting the oxygen flow fast enough only to maintain the desired degree of anaesthesia. The oxygen regulator will assist in determining the proper flow of oxygen.

The *depth* of anaesthesia is regulated by the amount of oxygen which is mixed with the nitrous oxide. Too much oxygen will bring the patient out; not enough will produce asphyxia. The symptoms of anaesthesia are the guide to the amount of oxygen to use.

The proper amount of oxygen, producing the normal plane of anaesthesia, is accompanied by smooth, regular respirations of from 25 to 30 a minute; the pupils are normal in size, or slightly smaller; they do not react to light and the conjunctiva is insensitive with the upper lids and the general musculature of the body quiet and relaxed. The color of the skin varies in different patients from a pink to a slightly dusky tint.

More oxygen is needed in the mixture when the patient forcibly exhales; has dilated and fixed pupils; is rigid or jerks convulsively in various muscles of the body, associated with any degree of cyanosis.

Less oxygen is required when the patient groans or cries out; with respirations that vary voluntarily; when the pupils react to light quickly; the eyelids resist opening and wink when the conjunctiva is touched; and when the extremities move purposely. The skin is usually pink in color.

It is important during prolonged anaesthesia that the mask be held against the face so that it is airtight and the chin and jaw be held up and forward so that breathing is free and easy.

THE ZONES OF ANAESTHESIA AND ANALGESIA WITHOUT SUPPLEMENTAL NARCOSIS. — To even more thoroughly understand the significant principles underlying the technique of nitrous oxide-oxygen anaesthesia and analgesia, it is important to consider briefly the researches of Karl Connell and James T. Gwathmey, of New York City, Walter M. Boothby, of Rochester, Minn., and Chas. K. Teter, of Cleveland, in charting the zones of avail-

PERCENTAGE IN TIDAL GASES		ZONE	DEPTH OF ANAESTHESIA	DEGREE OF ASPHYXIA	DEGREE OF RELAXATION	COLOR	UTILITY
NITROUS OXIDE	OXYGEN						
100%	0%	LETHAL	COMPLETE	GREAT TO FATAL	TONIC & CLONIC SPASM	BLUE BLACK	EXTRACTION of TEETH INCISION OF ABSCESS (USE CONDEMNED)
97%	3%						
95%	5%	PROFOUND	COMPLETE	CONSIDERABLE (DANGEROUS)	ASPHYXIAL RIGIDITY	DEEP CYANOSIS	
94%	6%	DEEP	COMPLETE	PARTIAL (DANGEROUS)	PARTIAL	MODERATE CYANOSIS	
92%	8%	MEDIUM	COMPLETE	PARTIAL	PARTIAL	SLIGHT CYANOSIS	INDUCTION
89%	11%	LIGHT	PARTIAL	SLIGHT	SLIGHT	FAINT CYANOSIS	ABDOMINAL SURGERY
86%	14%	VERY LIGHT	PARTIAL	0	0	NORMAL "ROSE COLOR"	SURFACE SURGERY (OR ABDOMINAL SURGERY WITH SUPPLEMENTAL NARCOSIS)
84%	16%	SUB CONSCIOUS ANALGESIA	PARTIAL COMPLETE ANALGESIA	0	0	NORMAL TO PINK	
80%	20%	LIGHT SUB CONSCIOUS ANALGESIA	ANALGESIA		0	PINK	
50%	50%	CONSCIOUS ANALGESIA	EQUAL PARTS OF AIR ALLOWED			NORMAL	DENTISTRY

Diagramatic Chart. Showing the Zones of Analgesia and Anaesthesia, without Supplemental Narcosis, as Worked out Clinically and Experimentally by Connell, Gwathmey, Boothby and Teter.

able nitrous oxide-oxygen anaesthesia and analgesia in normal man without supplemental narcosis.

"The intensity of the anaesthetic action of nitrous oxide," Connell explains, "is, in a measure, inversely as the quantity of oxygen with which it is administered. * * * Additionally the anaesthetic action is directly proportional to the tension of the gas dissolved in the blood and central nervous system. * * It must also be recognized that the proportion of the gases in the tidal volume is only an approximate index of the proportion of available gases which reach the nervous system. *Oxygen is perishable in the body and must be constantly refreshed, whereas with nitrous oxide, no loss being sustained, a partial, clinical balance of blood and neuron and alveolar gas is established within six minutes, an almost complete balance within fifteen minutes and a complete physical balance within forty minutes, if analogy with carbon dioxide may be drawn.* Thus small tidal volume, any diminished rate of blood flow or oxygen carrying capacity of haemoglobin must be compensated for by increase of oxygen relative gas pressure in obstructed breathing, acapnia, over-dosage, anaemia, sepsis, asthenic states, old age and cardiac decompensations. * * * In practice it is found that a refreshing of the gas at a rate about equivalent to the bulk of normal tidal volume suffices."

THE QUESTION OF REBREATHING.—This brings us to a consideration of *rebreathing* in nitrous oxide-oxygen anaesthesia. Rebreathing is advocated by some and denounced by others, and consequently it is important to understand its underlying principles and the technique of administration so that it may be used intelligently, when indicated, and *without prejudice.*

Supplementing the earlier investigations of W. D. Gatch, of Indianapolis, at Johns Hopkins University, in 1910, McKesson introduced the *fractional method of rebreathing*, and constructed a special device for its experimental investigation and clinical use.

This device is a cylindrical bag of thin rubber attached to a gas tight ring which slips over a cylindrical tube with a perforated bottom. By moving the ring and bag up and down the capacity of the bag, when in use, is known at all times and may be accurately adjusted as required. As *only a portion* of each breath is retained this is actually a fractional rebreathing device. The bag is attached to the nitrous oxide-oxygen apparatus between the supply bags

and the inhaler so that on exhalation the rebreathing bag is first filled and the latter part of the exhalation escapes through the expiratory valve on the face mask. On inhalation, the bag is first emptied and the remainder of the inhalation comes from the fresh gases in the supply bags. In this way the action is automatic, accurate and prevents the danger of asphyxia, from lack of control or experience, always a danger when total or uncontrolled rebreathing is used.

As a means of determining *how much* of each breath should be retained and rebreathed the bag is used *to measure* the *tidal* respiratory capacity of the patient before narcosis and from time to time during anaesthesia. This is accomplished by moving the ring and the bag down until the bag is just large enough to be filled and emptied with each breath. The graduation on the cylinder in cubic centimeters then represents the *tidal volume.*

A brief review of some facts in the physiology of *respiration* will show the importance of this method. The *average* lung capacity in *forced inhalation* is about 3,700 cc., but the amount of air inhaled and exhaled at an *ordinary breath* is only about 500 cc., called the *tidal volume.*

The tidal respiration may be divided into two portions: the first which fills the tubes and passages leading *to* the alveoli; and the *second*, which *occupies* the smaller bronchioles and alveoli where the exchange of gases actually takes place.

The quantity normally contained in the upper air passages and bronchial tree, in which there is no carbon dioxide, is 140 cc., while the second or alveolar portion amounts to 360 cc., and represents the volume of gases actually engaged in respiration.

The fractional rebreathing device has been constructed to retain the *first* portion in order to save the 140 cc. of unused gases. Since this 140 cc. contains no carbon dioxide, it could be of no other use than the saving of approximately one-fourth of the gases used by the patient, and therefore, represents economy. Moreover, this 140 cc. has lost none of its nitrous oxide or oxygen to the blood, and should not be wasted. If this were all that one would wish to be rebreathed a 140 cc. bag to catch these gases would be simplicity itself. But it is usually necessary to save more than 140 cc. of each exhalation in order to prevent *over-ventilation.* The amount actually used for

rebreathing must be adjustable and based upon the variable ventilation of the patient.

The normal ventilation of a sleeping adult is about (15 respirations times 500 cc., or) 7,500 cc. of air a minute. Under anaesthesia the patient often breathes rapidly, 30 respirations of 500 cc. or 15,000 cc. a minute. In other words, the ventilation is doubled. This is *over-ventilation.* To restore this over-ventilation to normal by means of fractional rebreathing, the bag is set to catch 250 cc. At each breath this accurate selection is automatically accomplished, and so long as the respiratory rate or volume does not change, no further adjustment is required and the patient actually exhales but 7,500 cc. a minute, although the respiratory movements would double this amount if half of each breath were not rebreathed.

Rapid breathing in anaesthesia, especially with nitrous oxide, is probably due, in part, to restricting oxygen to the nerve cell to amounts capable of supporting life-functions only. This oxygen restriction sets up a train of protective impulses resulting in rapid respirations, for it is common knowledge among nitrous oxide-oxygen anaesthetists that a rich oxygen mixture for two or three breaths will invariably slow and sometimes even stop respiratory movements for several seconds; but as the surplus of oxygen is consumed the patient soon resumes rapid respiration.

Therefore, the rate of respiration during nitrous oxide-oxygen anaesthesia depends partially upon the oxygen content of the mixture administered, increasing as the oxygen is decreased until such a point is reached that anoxaemia begins to produce either convulsive or spastic movements.

Since anaesthesia cannot be maintained in the presence of an excessive amount of oxygen in the mixture, we are compelled to tolerate rapid respirations in this as in ether anaesthesia, but we can prevent over-ventilation by rebreathing.

These rapid respirations, resulting in over-ventilation, eliminate more carbon-dioxide from the blood than normal, which in some patients causes a decreased volume of respiration, thus partially correcting the over-ventilation. In the majority of patients, however, associated with this rapid respiration, other symptoms indicative of shock appear, such as increased pulse rate, weak-

ened heart contractions, as shown by the decreased pulse pressure, as well as decreased systolic and diastolic blood pressures.

While over-ventilation is only one among the many causes of shock, and not even as important as trauma, it is almost invariably associated with shock from any cause and may always be a contributing factor when present. It is, therefore, of importance that this cause be eliminated in each case, *especially in hazardous risks under operation during pregnancy or labor.*

In clinical practice over-ventilation may be prevented by allowing the patient to exhale between 7,000 and 9,000 cc. of gases from the apparatus a minute. Thus the elimination of an excessive amount of carbon dioxide can be controlled.

Clinical Application of Fractional Rebreathing. — "Since using the fractional method of rebreathing," continues McKesson, "I have found that with a tidal volume of less than 300 cc., the resulting anaesthesia under nitrous oxide-oxygen is often unsatisfactory, doubtless due to an inadequate exposure of the gases in the alveoli for absorption. This may account for the efforts of some anaesthetists to increase the efficiency of nitrous oxide-oxygen under 5 mm. of increased atmospheric pressure. When an adult patient has a tidal volume of 300 cc. or less the rebreathing bag should be set so that a considerable portion of this is rebreathed for a minute or so until enough carbon dioxide is thus retained to stimulate the depth of respiration to about the normal, or 500 cc. When approximately the normal volume is secured, the rebreathing bag is readjusted on the basis of the rate of respiration then prevailing. Generally the volume may not be increased *above* the normal without stimulating the rate of respiration, which is usually undesirable. The increased volume of respiration exposes more nitrous oxide-oxygen to the blood for absorption, and a deeper anaesthesia is obtained without changing the mixture of the gases. Within certain limits rebreathing may be used to stimulate the *depth* of respiration, while the rate may be varied somewhat by the proportion of oxygen in the mixture. The latter is, however, less susceptible of manipulation, as previously explained.

Effects.—The occasional necessity of administering ether with nitrous oxide-oxygen, which is usually due to faulty preparation of the patient, lack

ON MEDICAL
MAY 10 1922
LIBRARY

of skill in the anaesthetist or roughness on the part of the surgeon, does not interfere with the routine use of rebreathing by the fractional method. Rebreathing during the administration of nitrous oxide-oxygen will not only control the tendency of preliminary alkaloidal medication to decrease the rate and volume of respiration, but will also, in association with over-ventilation, conserve the quantity of ether when used as a supplemental anaesthetic.

Opinions.—Owing to the diversity of opinion among certain authorities on this subject, some of them are herewith quoted on the question of *rebreathing* in obstetrical nitrous oxide-oxygen analgesia and anaesthesia.

Davis makes the following commentary: "Rebreathing may be practiced to some extent in nitrous oxide-oxygen analgesia. The use of rebreathing in the normal labor case will reduce the cost of analgesia about 50 per cent; but if it is continued over a long period, the patient may complain of symptoms similar to those produced by sleeping in a stuffy room. She is apt to have a headache and complain of a bad taste in the mouth. If rebreathing is practiced it is advisable to give the patient pure oxygen for several minutes after the termination of labor."

Guedel holds that: "The principal advantage of rebreathing in this work is economy. In continuous analgesia or narcosis (with certain apparatus) it serves to warm the gases, thus fortifying against the possibility of irritation of the upper respiratory passages. The character of results, the safety and comfort of the patient, do not seem to be unfavorably influenced by it. As a rule about 50 per cent of the entire volume of gas is rebreathed; but this must, at times, be decreased to meet special indications. The refractive patient will usually respond better with a smaller rebreathing volume. Retention of carbon dioxide, as accomplished by rebreathing in major surgical narcosis, for the purpose of respiratory and cardio-vascular stimulation in the mother, has never been indicated to my knowledge in obstetrics, under the administration of nitrous oxide."

Ferguson is decidedly opposed to rebreathing: "In studying a series of one hundred cases in my own practice," he says, "in which nitrous oxide-oxygen was administered by my own trained nurse, I have reached the following conclusions: (1) That more than 25 per cent of babies delivered by nitrous oxide analgesia show slight crowing inspiration, immediately after birth,

which may last for 24 to 48 hours. This is an entirely different condition from that encountered when mucus has been drawn into the larynx. It is more like a slight paralysis of the epiglottis with a resulting snoring sound. (2) That this condition of crowing respiration (inspiration) is very much exaggerated when *rebreathing* is used to any extent. (3) *That this condition of crowing inspiration is never present for more than a few breaths if the mother is given plenty of oxygen while the cord is still pulsating, but that it may last for hours if oxygen is not given.* (4) Unusual muscular twitching lasting for about 24 hours, but not seen if oxygen is used freely for the first twelve hours after birth. (5) That every baby showing a crowing inspiration at birth, or where the mother during labor has complained of a marked dryness of the throat while taking nitrous oxide, should be allowed to absorb all the oxygen possible from the mother before the cord is tied, the mother receiving pure oxygen until the cord stops pulsating. * * *

"From my study of 8,000 collected cases with my own cases included, I have reached the following conclusions: (a) That *rebreathing* is extremely dangerous to the baby and has no place in obstetrics; (b) that *air and nitrous oxide* are less dangerous than *rebreathing;* but slightly more dangerous than when *oxygen* is used and not as efficient as *nitrous oxide-oxygen.*"

W. C. Danforth is also adverse to the use of rebreathing. He writes that: "Rebreathing, in my practice, is not permitted at any time while the child remains in the uterus."

Allen has discarded rebreathing on account of the danger to the unborn child, and also because analgesia and anaesthesia are not so even with it. Allen prefers to use fresh supplies of nitrous oxide with air or oxygen in individualized percentages.

On the contrary F. C. Irving, of Boston, has employed rebreathing extensively for purpose of economy, and although he has kept minute and accurate records has no untoward results to report.

NDER THE PROPER ADMINISTRATION OF NITROUS OXIDE IN LABOR, THE PATIENT IS NOT EXHAUSTED MENTALLY OR PHYSICALLY ¶ THE OBSERVER IS IMPRESSED WITH THE VIGOROUS PHYSICAL AND MENTAL POSTPARTUM CONDITION OF NITROUS OXIDE PATIENTS ¶ THEY DISPLAY LITTLE OR NONE OF THE USUAL DEPLETED APPEARANCE OF THE WOMAN HAVING LABORED WITHOUT ANALGESIA ¶ A NOTABLE RESULT OF THIS PROTECTION AGAINST EXHAUSTION OF THE MOTHER AND HER FREEDOM FROM BLOOD AND TISSUE CHANGES IS MANIFESTED IN THE EARLY APPEARANCE OF BREAST MILK OF GOOD QUALITY ¶ THE EARLY PUERPERIUM IS PLEASANTER, THE MOTHER REQUIRING COMPARATIVELY LITTLE ATTENTION ¶ THERE IS AN ACTUAL SHORTENING OF THE CONVALESCENT PERIOD ¶

—Arthur E. Guedel.

CHAPTER SEVEN
Mother and Child

Further Effects on Mother and Child ❧ Headache ❧ Control of Nausea and Vomiting ❧ Conservation of Muscle Tone ❧ Protection Against Hemorrhage, Acidosis and Bacterial Invasion ❧ Physical Well-Being of Mothers after Labor ❧ Early Flow of Milk ❧ The Reaction of Varying Types of Patients ❧ Handling Difficult Patients ❧ Primiparae and Multiparae. Effects of Nitrous Oxide Anaesthesia and Analgesia on the Child ❧ Mechanism of Protection ❧ Cyanosis ❧ Pink Babies ❧ Minimal Effects on the Unborn Child ❧ Time Limit of Administration ❧ Nitrous Oxide no Panacea for Poor Obstetrics ❧

ALTHOUGH THE FUNDAMENTAL physio-pathological effects of nitrous oxide-oxygen analgesia and anaesthesia have been rather thoroughly reviewed, there are certain other general effects on the mother and child which must not be overlooked. Perhaps the most unpleasant effect that has been noticed as occurring, with any recognized degree of frequency, is *headache*, usually of a mild and transitory character. This headache may be due to too intensive an administration of the nitrous oxide, rebreathing or an inadequate amount of oxygenation, permitting a very light degree of cyanosis over a long time. Thorough oxygenation after delivery goes far in avoiding this complicating aftermath.

Control of Nausea and Vomiting.—All observers are agreed that under nitrous oxide-oxygen analgesia and anaesthesia there is less nausea and vomiting than under any other form of general narcosis. A number of instances are on record in which nitrous oxide-oxygen has controlled the vomiting of parturient women.

Conservation of Muscle Tone: Protection Against Postpartum, Haemorrhage, Acidosis and Bacterial Invasion.—One of the drawbacks of nitrous oxide-oxygen anaesthesia in major surgery has been the skill required to secure proper muscular relaxation under its administration. This peculiar property of nitrous oxide-oxygen, of conserving rather than diminishing *muscle tone*, is a decided asset in obstetrical analgesia. Not only is uterine inertia avoided but the mother is protected, to a considerable extent, from delayed involution and postpartum haemorrhage. Even the consistent advocates of chloroform in labor cannot deny the fact that their statistics show a disproportionate incidence of postpartum haemorrhage in comparison with the occurrence of this serious complication under other methods of narcosis. Nitrous oxide of all anaesthetic agents least affects the coagulability of the blood and the coagulation time, and it is really remarkable how the oxygenation of the patient, after nitrous oxide anaesthesia, will almost instantly control any tendency to haemorrhage. The conservation of the blood supply, the prompt expulsion of the placenta and the rapid involution of the uterus render the prospects of bacterial invasion, following labor, almost a negligible factor. While ergot is still given rather routinely after childbirth, its administration is rarely necessary after a properly conducted nitrous oxide labor. Pituitrin should also be used with caution and discretion.

It must be candidly acknowledged that in view of the more recent researches in the relation of ether and etherization to infection and immunity that much of the previous disrepute attaching to this anaesthetic no longer holds good. Limitation of proper oxygenation during ether anaesthesia has been responsible for many of the complications following its surgical narcosis and inattention to the conservation of the alkali reserve has accounted for many of the catastrophes blamed on delayed ether poisoning.

When nitrous oxide-oxygen is not available, Davis considers that ether may be administered in a similar manner with very beneficial results. Ether when completely vaporized seems to cause less irritation than when inhaled direct from the customary gauze covered face mask. The chief advantage, in Davis's opinion, of giving oxygen with ether is due to the complete vaporization secured.

Recently James H. Cotton, of Toronto, has been experimenting to produce an ethylene ether capable of providing dependable ether analgesia. Suf-

ficient data on the use of this new ether in obstetrics, either as an analgesic or as a supplemental anaesthetic, is not yet available for any opinion on its merits.

A. Ficklen, of New Orleans, La., after some experience with oral analgesia and anaesthesia, by the administration of various formulas of anaesthetics and narcotics in oil, both in war and civilian surgery, has reported favorable results with the same method in eight collected cases of its use in obstetrics. Some thousands of cases will have to be reported, however, before any definite conclusions as to the worth of oral analgesia in obstetrics can be established.

However, of all anaesthetic agents in routine use, nitrous oxide, of itself, has the minimal deleterious action on the tissues of the body and its organic functions; while during its administration absolute oxygenation of the body can be carried out,—a thing which is not entirely possible with the lipoid solvent anaesthetics. This accounts for the greater protective property of nitrous oxide-oxygen against postoperative acidosis and bacterial invasion due to lowered resistance, decreased phagocytosis and decreased haemoglobin content.

WELL BEING OF MOTHER AFTER CHILDBIRTH.—Guedel also emphasizes that: "Under the proper administration of nitrous oxide in labor, *the patient is not exhausted mentally or physically.* The general postpartum condition is better than in cases delivered without an anaesthetic or with the anaesthetic applied during the last few minutes of labor, as is the common custom with chloroform and ether. The observer is impressed with the vigorous physical and mental postpartum condition of nitrous oxide patients. They display little or none of the usual depleted appearance of the woman having labored without analgesia. A notable result of this protection against exhaustion of the mother and her freedom from blood and tissue changes is manifested in the early appearance of breast milk of good quality. Following delivery some mothers are wide awake and talkative, others show a normal tendency to sleep. The early puerperium is pleasanter, the mother requiring comparatively little attention. So constant is this that it is noticed and appreciated by the obstetrical nurse. There is an actual shortening of the convalescent period. More rapid involution, more favorable recuperation in general, all of which renders it advisable to permit these patients to leave bed a day or two earlier. They are actually a day or two nearer the norm at the end of the first week and confinement, longer than necessary, is harmful in any case. Fewer visits to

the bedside are required, and the freedom from annoyance of little things wrong during this period is noticeable to the physician."

Reactions of Varying Types of Patients. — Certain types of patients co-operate and react differently to analgesia during labor. The result should be regarded as unfavorable if the parturient woman moves sufficiently to disarrange the linens or to interfere with proper aseptic technique.

Common sense and a desire to co-operate play a more important part in making the woman in labor a satisfactory subject for nitrous oxide analgesia than elaborate educational qualifications. Some observers maintain that persons of sluggish or defective mentality are comparatively immune to the analgesic and anaesthetic effects of nitrous oxide, but the more logical explanation would seem to be that persons of such mentality fail entirely to appreciate their part in making the technique of administration successful. Klikowitsch and Doederlein, the earliest investigators, remarked that suffering during labor under analgesia was usually relieved in proportion to the intelligence of the patients.

Nervous patients, irrespective of their type of mentality, are difficult and unsatisfactory subjects for analgesia or anaesthesia. They are apprehensive, fearful and not co-operative and confuse every sensation associated with labor as pain or disaster. Nevertheless once delivered under analgesia they demand it in future labors, in which they are usually less troublesome.

In this connection the obstetrician and anaesthetist should recall, as McMecham has pointed out, that: "*The various sensations during the induction of analgesia, its continuance or during lapses into anaesthesia and vice versa, are not unpleasant, but they are unusual and unexpected, and unless patients are familiar with their character and sequence, they may misinterpret these normal sensations as symptoms of approaching faintness, collapse or dissolution.*"

Handling Difficult Patients.—Frequently somewhat unmanageable patients during the first half-hour of labor will quiet down and begin effective co-operation, after appreciating that analgesia is really pain relieving. Occasionally permitting such patients to lapse into anaesthesia will convert them to the efficacy of the method and enable the attendant to resume analgesia

or withholding the inhalations during a severe pain may be effective in securing co-operation and showing the patient the relief that has been given her.

Women show the discomfort of labor in different ways and not infrequently, even under satisfactory analgesia, may groan, squirm and mutter, but these reactions are often subconscious and are not remembered, and sometimes they are in reality a mild excitory stage of nitrous oxide analgesia before it lapses into narcosis. Evans considers that even "if patients laugh, cry, sing or utter connected articulate speech, and at the same time are free from pain, they may be considered to be within the zone of analgesia." Neurotic patients, in whom analgesia may have seemed unsatisfactory, will, after the completion of labor be found to have had a *complete amnesia.*

PRIMIPARAE AND MULTIPARAE.—*Primiparae* are occasionally disappointed with a nitrous oxide labor because they have no conception of the suffering they have been spared and are inclined to exaggerate the experience they have passed through. The sensible types of primiparae, however, when tactfully handled, can be satisfactorily helped through labor with nitrous oxide without resorting to the more vigorous discipline of one or two pains without analgesia.

Multiparae, having experienced a previous labor with ether or chloroform, or without any anaesthetic, are able to appreciate the comparative relief of nitrous oxide and, as a class, are the most satisfactory patients and most grateful. They know what is expected of them and assist voluntarily not only in facilitating the analgesia but also in promoting the progress of labor.

Indolent multiparae, who are not inclined to co-operate should be handled under continuous analgesia or chastised by allowing them to suffer a pain.

Physical types, presenting embarrassed respiration, obstructed airway or decreased respiratory capacity, may have some difficulty in securing sufficiently rapid analgesia to control the pain of uterine contraction, previous to its climax. On the contrary, alcoholics and drug habitues, while difficult to handle, respond to analgesia more favorably than one would expect from their reaction to surgical anaesthesia.

EFFECTS OF NITROUS OXIDE AND ANALGESIA ON THE CHILD.—Nitrous oxide anaesthesia or analgesia, properly administered to the parturient

woman, need have no ill-effect, directly or indirectly, upon the child. Many of the pioneers in this form of obstetrical pain-relief have remarked the fact that babies, born of mothers who at the moment of birth were deeply cyanosed, were not blue. Their color compared very favorably with that of new-born infants in deliveries conducted without anaesthesia and not unduly prolonged.

Unlike the lipoid solvent anaesthetics nitrous oxide is not transmitted to the child *in utero* in anaesthetic doses. This is apparent from the early resuscitation of infants born by Caesarean section under nitrous oxide anaesthesia.

Mechanism of Protection. — This peculiar limitation of nitrous oxide effect may be readily explained, and Guedel details it as follows: "Under individual pain administration, the babe *in utero* or in the birth canal, receives but little nitrous oxide from the mother, no matter how great may be the excess of nitrous oxide in the mother's blood during the acme of uterine contraction. Administration of the nitrous oxide is begun with the first evidence of each pain. Analgesia progresses to the point of greatest depth usually at the acme of uterine contraction, the first evidence of anoxaemia becoming manifest at this time. During the period of induction, when the nitrous oxide is entering the blood of the mother, the uterus is contracting, so that there is little, if any, interchange of foetal and maternal blood. The babe lives during the uterine contraction upon well oxygenated placental blood accumulated between pains. The anaesthetic is removed at the acme of contraction, and as only 10 to 30 seconds are required to eliminate the excess of nitrous oxide from the mother's circulation, it is evident that the blood of the infant receives but little nitrous oxide during the period of uterine relaxation. By the time the uterus is sufficiently relaxed to permit an interchange of blood the circulation of the mother is almost free from nitrous oxide and is again well ventilated. * * *

"In *continuous analgesia* the necessary dose of nitrous oxide is so small that were it given to the babe direct it would hardly be sufficient to anaesthetize."

Cyanosis.—Intermittent marked cyanosis or mild degrees of continued cyanosis invalidate the safety of nitrous oxide analgesia and anaesthesia to both mother and child, but with proper air or oxygen admixture avaliable there is no excuse for the occurrence of cyanosis. Those women, who hold the breath

so long during expulsive effort as to become cyanotic when analgesia is not used, may be kept pink under analgesia by the use of oxygen in proper amounts.

Pink and Blue Babies.—Blue babies are no more frequent in nitrous oxide labor than in labor with or without other anaesthetics. The necessity for artificial resuscitation is rare, and if it arises oxygen is at hand for oxygenating the mother's circulation before the cord is tied off, or oxygenating the infant afterward by insufflation. "*A tedious and long delayed second stage,*" *as Polak has repeatedly pointed out,* "*is to blame for more blue babies than the effects of any anaesthetics.*" Aside from complications involving the integrity of the circulation in the cord, signs of life appear promptly in all infants born under nitrous oxide, the majority of babies crying lustily within five seconds after delivery, and not infrequently before they are born. This fact has been beautifully demonstrated in the moving picture of a nitrous oxide delivery, shown at the recent Cincinnati meeting, 1919, of the Interstate Association of Anaesthetists and American Association of Obstetricians and Gynecologists, by C. E. Turner and W. I. Jones, of Columbus, Ohio, although *continuous analgesia* was the technique used and the cord was prolapsed.

Early Flow of Milk and Conservation of Weight.—It is also the concensus of opinion among many observers that nitrous oxide labor results in so normal a puerperium that lactation appears unusually early and the breast milk is of good quality and quantity, and as a result the baby is early and well fed. The infant does not show the annoying symptoms of hunger, crying and restlessness observed so routinely with older methods of anaesthesia and confinement. It need not wait 72 hours for the milk to come in. The proportionate loss of its initial weight is less and its gain in weight begins earlier. Also the analgesia baby does not show intestinal distress to the same degree as one born of an etherized or exhausted mother, and is able to assimilate and digest its food to better advantage from birth.

As previously remarked, Morris H. Clark, of Kansas City, in his first series of 100 nitrous oxide labors, noted a reduction in the incidence of infantile jaundice from 25 to 12 per cent.

The Minimal Effects of Nitrous Oxide-Oxygen on the Unborn Child.—The minimal effects of nitrous oxide-oxygen anaesthesia on the

unborn child in emphasized by John R. Worley, of Dallas, Texas, who in a discussion of the subject before the American Association of Anaesthetists, remarked that "*in an extended experience he has not seen an abortion or miscarriage or premature birth in any mother, operated on for some complicating pathology during pregnancy under this form of anaesthesia; and so far as he had observed all these unborn infants had gone to term and had been delivered alive.*"

TIME LIMIT OF ADMINISTRATION.—While delivery under nitrous oxide may be precipitate, especially in multiparae, obstetricians are inclined to set a time limit of three hours on the administration of nitrous oxide analgesia, lest its cumulative effect may exert an untoward influence on either the mother or the child. In this connection it must be remarked that many expert anaesthetists have reported prolonged administrations of gas and oxygen in labor without disastrous effects, but in these instances labor has most probably been normal and not complicated by toxaemia, contracted plevis, mal-positions, and other difficulties which of themselves endanger either the life of the child or the welfare of the mother if not properly and expeditiously handled.

In this connection, also, R. Ferguson, from the study of his own and his collected cases, further concludes: (a) That nitrous oxide-oxygen, when used longer than three hours, becomes dangerous to the baby by reason of the haemolysis which occurs in the mother's blood and may also occur in the foetal circulation. (b) That babies are safe for three hours of nitrous oxide labor, providing the mother is never allowed to become cyanosed and nitrous oxide is not used above 80 per cent, the other 20 per cent of the mixture being oxygen, not air. (c) That when nitrous oxide is used longer than three hours there is danger of a condition developing in the baby simulating the late deaths from chloroform or ether narcosis. Since carbon dioxide and nitrous oxide do not, in any way, combine with the haemoglobin of the blood, but only starve the body cells of oxygen and thereby cause retention of the acid products of metabolism, this condition in the baby or even in the mother is most probably a nitrous oxide acidosis. (This contention of Ferguson is in agreement with the researches of Casto on blood changes, already quoted.) Finally, Ferguson concludes (d) that when nitrous oxide is used in a high degree of concentration for longer than three hours, the baby should receive not only all the oxygen possible before the cord is tied, but should be further resuscitated by the giving

of pure oxygen, more or less continuously, for from 24 to 48 hours after birth. This should be done as a routine to avoid the occurrence of acidosis.

Nitrous Oxide no Panacea for Poor Obstetrics. — There is nothing to be gained by blaming nitrous oxide for a dead baby delivered by version after prolonged labor when it could have been saved by earlier interference or Caesarean section. In this connection Davis deserves great credit for reiterating that it is *eutocia not anaesthesia* which is life-saving. Nitrous oxide is no panacea for poor obstetrics.

Granted skillful administration and normal labor there is practically no time limit to nitrous oxide analgesia. It has been administered in hundreds of cases with entire safety for from 3 to 8 hours, and in some instances for even longer periods. R. C. Coburn, of New York City, has recently reported a number of nitrous oxide-oxygen administrations in labor of 9 hours' duration without untoward effects on the mother or child. Its one advantage over all other anaesthetics is that if it does anything it shortens and facilitates the second stage of labor, which is usually the endangering phase both to the mother and child.

The present tendency is to begin the administration of nitrous oxide sooner than formerly, at least toward the end of the first stage of labor. This is in keeping with Winckle's observation that:

"*Women to whom it is not administered until the stage of expulsion can seldom be induced to inhale it quietly, while when administered in the first stage of labor its beneficent action is at once felt and extends to the second stage.*"

It is apparent from the results of W. C. Danforth, of Evanston, (quoted later on) that the longer the duration of nitrous oxide-oxygen analgesia within reasonable limitations, the more satisfactory it becomes, without any apparent untoward damage to mother or child directly traceable to the analgesia.

HILE THE PROPER USE OF NITROUS OXIDE-OXYGEN ANALGESIA AND ANAESTHESIA, IN NORMAL LABOR AND OPERATIVE OBSTETRICS, MAY DO MUCH TO SAFEGUARD THE LIVES OF BOTH MOTHER AND CHILD, THE HOPE OF REDUCING THE MORBIDITY AND MORTALITY OF OBSTETRICS, WHICH ARE STILL APPALLING, AS COMPARED WITH THE RESULTS IN OTHER PHASES OF MEDICINE AND SURGERY, RESTS MUCH MORE ON THE DISPOSITION OF THE MIDWIFE, WHO DELIVERS FIFTY PER CENT OF THE PARTURIENT WOMEN IN THE LARGER CITIES, THAN ON ANYTHING ELSE ❧ IN THIS FACT MEDICINE FACES A PROBLEM OF VAST ECONOMIC IMPORTANCE TO THE PUBLIC, WHICH IS SINGULARLY PARALLEL TO THE PROBLEM OF PROFESSIONAL ANAESTHESIA ❧

—*E. I. McKesson.*

CHAPTER EIGHT
Studies of Results

Davis's Statistical Analysis of His Results ❧ Forceps and Pituitrin ❧ Average Stay in Hospital ❧ Duration of Labor ❧ Weight of Babies at Birth ❧ Lacerations ❧ Mortality ❧ Postpartum Haemorrhage ❧ Discussion and Conclusions ❧ Records and Results of Cherry ❧ Danforth's Experiences ❧ Method of Administration ❧ Details of Results ❧ Condition of Babies at Birth ❧ Puerperal Insanity ❧ Other Available Statistics ❧

SEVERAL observers have collated their statistical records with nitrous oxide in labor, and a review of these, in some detail, as given by these obstetricians and anaesthetists, speaks for their results. Their perusal, however cursory, cannot but convince those who are interested that this method of obstetrical pain-relief has come to stay. Davis, while connected with the Obstetrical Department of the Presbyterian Hospital, Chicago, was among the first to make a statistical analysis of his results.

Davis's Statistical Analysis of his Results.—A careful study of 104 consecutive cases, admitted to the maternity ward of the Presbyterian Hospital, was made in order to learn the facts * * * The technique of administering the analgesia was the same for all cases in the series and they had the same postpartum care. The nitrous oxide-oxygen analgesia was administered to all patients who requested it, provided they could pay for the gases used as the hospital was not able to furnish them free, except in such cases in which the condition of the patients rendered it imperative to make labor as easy as possible.

For purposes of study the cases were divided into two groups:

Group 1 was made up of 50 cases that had nitrous oxide analgesia and 9 cases that had the analgesia supplemented with ether for delivery. There were in this group 44 primiparae and 15 multiparae.

Group 2 was made up of 45 cases that had for the most part no analgesia, some having morphine during labor and some ether during delivery. There were in this group 18 primiparae and 27 multiparae.

TABLE I. FORCEPS AND PITUITRIN.—Group 1. *Primiparae:* Low forceps were used three times; 1 L. O. P. and 2 R. O. P.; Pituitrin before delivery four times. *Multiparae:* Low forceps were used once in a case of mitral stenosis and pituitrin was administered before delivery once.

Group 2. *Primiparae:* Low forceps were used twice because of maternal exhaustion, both in L. O. A. positions. Pituitrin was used once before delivery. *Multiparae:* There were no forceps deliveries; Voorhees bags were used twice; and pituitrin was administered twice before delivery. Version was performed once in each group for transverse presentations in each instance.

TABLE II. AVERAGE STAY IN HOSPITAL.—Group 1. *Primiparae:* 10.8 days after delivery. *Multiparae:* 11.9 days after delivery. Several were admitted in a greatly weakened condition which made the longer stay necessary.

Group 2. *Primiparae:* 12.2 days after delivery. This does not include one case that developed a puerperal sepsis and remained in the hospital 37 days. *Multiparae:* 11.1 days after delivery.

TABLE III. DURATION OF LABOR.—Group 1. *Primiparae:* Averaged 13.5 hours. *Multiparae:* Averaged 7.33 hours.

Group 2. *Primiparae:* Averaged 17.9 hours. *Multiparae:* Averaged 10 hours.

TABLE IV. WEIGHT OF BABIES AT BIRTH.—Group 1. *Primiparae:* Babies averaged 7 lbs. 5 ozs. (21 males and 23 females). *Multiparae:* Babies averaged 7 lbs. 12 ozs. (7 males and 8 females).

Group 2. *Primiparae:* Babies averaged 7 lbs. (13 males and 5 females). *Multiparae:* Babies averaged 7 lbs. 2 ozs. (12 males and 15 females).

TABLE V. AVERAGE LOSS IN WEIGHT OF BABIES. — Group 1. *Primiparae:* Babies lost 7.8 ozs., or 6.7 per cent of their body weight, the losses ranging from 0 to 16 ozs. *Multiparae:* Babies lost 9.4 ozs., or 7.58 per cent of their body weight, the losses ranging from 5 to 19 ozs.

Group 2. *Primiparae:* Babies lost 7.9 ozs., or 7.14 per cent of their body weight, the losses ranging from 4 to 13 ozs. *Multiparae:* Babies lost 8.4 ozs., or 7.37 per cent of their body weight, the losses ranging from 3 to 14 ozs.

TABLE VI. LACERATIONS.—Group 1. *Primiparae:* 36 primiparae delivered with nitrous oxide-oxygen analgesia had 23 lacerations; 20 slight or first degree, 2 second degree and 1 episiotomy.

Eight *primiparae* with nitrous oxide-oxygen analgesia during the painful stage with ether substituted for delivery had 7 lacerations; 3 slight or first degree, 3 second degree, 1 episiotomy. The babies of these 8 averaged 8 pounds.

Group 2. Eighteen *primiparae* delivered with ether or no anaesthetic had 14 lacerations; 7 first degree and 7 second degree.

TABLE VII. MORTALITY.—Group 1. There was no maternal or foetal mortality.

Group 2. One *primiparae* with a second degree tear developed puerperal sepsis, although she did not have a vaginal examination. She was in the hospital 37 days, but made a good recovery. There were 3 foetal deaths; 2 premature babies of about 7 months and 1 from injury of the after-coming head in a breech delivery.

TABLE VIII. POSTPARTUM HAEMORRHAGE.—Group 1. There were no cases of postpartum haemorrhage.

Group 2. There was one case of postpartum haemorrhage in a case delivered under ether.

DISCUSSION.—This series is small but it includes all the cases entering the Maternity Department during a period of about four and a half months, except 3 Caesarian sections operated on in the gynecological clinic, which have

no value in this study. The house cases all had the same after-care, which included active and passive exercise, sleeping on the stomach, backrest during the first few days, sitting in a chair on the fourth to seventh day, and home as soon as the patient was strong enough to go with perfect safety. But these statistics also include a few patients of physicians who kept their patients in bed from 10 to 15 days. It is also of interest to note that these patients seemed weaker after the long stay in bed than the other patients did after only six or seven days.

Conclusions.—From a study of the accompanying tables certain facts seem worthy of more than passing consideration. A study of larger series of cases will undoubtedly alter, to some extent, the percentages here recorded, but from our experience we believe that the general conclusions will not be materially changed.

1. A group of 44 *primiparae*, who had nitrous oxide-oxygen analgesia, had an average labor of 13.5 hours while 18 *primiparae*, who had no anaesthetic or ether during delivery, had an average labor of 17.9 hours, even though the average weight of their babies was 5 ounces less. The 16 *multiparae*, who had analgesia, had an average labor of 7.33 hours, and the 27 *multiparae*, who had ether or nothing, had an average labor of 10 hours, yet their babies averaged 10 ounces less than those in the first group. Nor was the duration of labor among the unaided cases unusually long. "Speigelberg found in 506 cases that the average for *primiparae* was 17 hours and for *multiparae* 12 hours." (Webster.) Hence it would appear that labor was shortened about 25 per cent by the use of nitrous oxide-oxygen analgesia.

2. Although the patients had the same postpartum care and were for the most part discharged when strong enough to return home with safety, this study shows that the 44 *primiparae* who had the analgesia had an average stay in the hospital of 10.8 days after delivery, whereas the *primiparae* of the other group had an average stay of 12.2 days after delivery. The extra stay of a day and a half will nearly pay for the gases used in ordinary labors.

3. The use of nitrous oxide-oxygen analgesia does not interfere with the supply of milk. The babies of the 44 *primiparae* who had the analgesia lost 6.7 per cent of their body weight, while the babies of the 18 *primiparae*,

who were not so fortunate, lost 7.14 per cent of their body weight. Since Holt states that the newborn loses an average of 11 per cent of its body weight, the average loss in this series is certainly in favor of nitrous oxide-oxygen delivery and four hour nursing periods.

4. The use of nitrous oxide-oxygen analgesia by assuring better control of the patients, apparently reduces the number and severity of the lacerations.

5. It is not necessary to change from the nitrous oxide to ether or chloroform in the majority of obstetrical cases. However, a hyper-sensitive uterus may necessitate an injection of morphine, or a change to ether or chloroform to lessen the frequency and severity of uterine contractions, but this can be controlled, at least in the majority of instances, by administering nitrous oxide-oxygen *anaesthesia* and then returning to *continuous analgesia* as is employed by dentists.

6. The use of nitrous oxide does not favor postpartum haemorrhage.

7. Nitrous oxide-oxygen analgesia may be used in all types of obstetrics. In the normal case and properly administered it has a 100 per cent efficiency. It may be used for versions, forceps and combined with novocaine infiltration for Caesarian section.

CHERRY'S RECORDS AND RESULTS.—Thomas H. Cherry, of New York City, has recently published the results of nitrous oxide-oxygen-chloroform analgesia at the Harlem Hospital in the Obstetrical Service of G. L. Brodhead. Individual pain administration of nitrous oxide-air has been the routine with brief chloroform anaesthesia for the short time the head is passing over the perineum.

"Of the 84 patients to whom analgesia was administered," writes Cherry, "38 were primiparae and 46 multiparae. Forceps deliveries occurred in 4 instances; three low and one medium forceps. In cases in which pituitrin was used for inertia, 4 were multiparae and 2 primiparae, making 6 in all or 7 per cent. There were 4 breech deliveries and 1 craniotomy in a contracted pelvis and a dead foetus. The systolic blood pressure was increased 15 mm. in one case, 19 mm. in 2 cases and 5 mm. in three cases. It was decreased 20 mm. in one instance and remained unchanged in 77 cases. The foetal heart beat

was unchanged in 82 cases, slowed 10 beats in one case and 20 beats in another. There was no maternal mortality. The foetal mortality was one and autopsy on this baby showed a congenital atelectasis. This baby's mother had nitrous oxide administered for 5 minutes. * * *

"There was one stillbirth; in this instance the foetal heart had not been heard throughout labor. In 25 cases there was complete analgesia, or 29.4 per cent. In 58 cases there was moderate analgesia, or 69 per cent. In one case analgesia was absent, or 1.6 per cent. In this last instance the absence of analgesia can be accounted for by the fact that the patient was refractory and did not breath properly. Amnesia was complete in 5 cases, moderate in 3 and absent in 76. * * *

"The length of time of the administration of nitrous oxide varied from 5 minutes to 4 hours and 25 minutes. Asphyxia of the child occurred in 3 cases; in each instance the umbilical cord was around the neck one to three times. All three infants were revived. Cyanosis of the child occurred in 2 cases, in the other there was no cyanosis. Cyanosis of the mother occurred moderately at the beginning of the nitrous oxide administration in one case and cleared up as labor advanced. One patient continued to have considerable cyanosis throughout. In the other 82 cases there was no cyanosis. The second stage of 32 primiparae averaged 1 hour and 55 minutes. The second stage of 31 multiparae recorded averaged 1 hour and 22 minutes. There was no postpartum haemorrhage resulting from secondary relaxation of the uterus. No uteri were packed. Ergot was given, however, as a prophylactic after the completion of the second stage in every case. * * *

"From the above series of cases recorded and analyzed, it can be deduced that, with nitrous oxide administered alone during labor, no ill effects upon the mother or foetus were noted; that the resort to forceps or pituitrin was not more necessary than in the average case of labor; that there was no tendency to postpartum haemorrhage; that the prolonged administration did not cause damage to the kidney or liver in so far as could be observed clinically."

DANFORTH'S EXPERIENCES.—W. C. Danforth, of Evanston, Ill., in 1917, compiled a statistical analysis of 476 cases of delivery under nitrous oxide analgesia. These records cover the cases handled at the Evanston Maternity from March, 1915, to February, 1917. In 1918 he added

187 cases to the series. The time of administration varied from a few minutes up to 7 hours. An accurate record was kept of all cases receiving analgesia in order that the effect on the mother and child might be definitely estimated. After the termination of each case a card was filled out showing the length of labor, effect upon pain, maternal and foetal heart, condition of baby at birth, character of analgesia, and character of puerperium, as well as length of patient's stay in the building.

METHOD OF ADMINISTRATION.—Individual pain administration with a face mask was used at the end of the first stage in primiparae and somewhat earlier in multiparae, the onset of contraction being felt by the hand on the abdomen. In some patients 3 or 4 deep inhalations of the gas sufficed for analgesia, while in others 8 or 10 breaths were required. Nitrous oxide alone was used in a considerable number of cases with refreshing breaths of oxygen to clear up the slightest cyanosis. In other cases from 5 to 10 per cent oxygen was added after the third breath. Continuous analgesia deepened to anaesthesia was used during the stage of expulsion. Ether was only used in the terminal stage of expulsion to avoid laceration from too strong pains and in operative procedures, although low forceps were satisfactorily used under nitrous oxide. Extensive repair occasionally required supplemental etherization.

DETAILS OF RESULTS. (FIRST SERIES)

Number of Cases	*Period of Time*	*Satisfactory*	*Fairly Satisfactory or Poor*
201	0 to 1 hr.	182	24
159	1 to 2 hrs.	140	19
79	2 to 3 hrs.	65	14
20	3 to 4 hrs.	19	1
5	4 to 5 hrs.	5	.
2	5 to 6 hrs.	2	1
3	6 to 7 hrs.	2	1

Taking the total number of cases we find that the percentage of *unsatisfactory* administrations was 7.5 per cent.

NOTE.—Reference to the history sheets in the *additional series* of 187 cases, shows that successful pain-relief is being attained in fully as high a percentage of cases as in the *first series*. In reviewing the preliminary draft of

the Monograph, Danforth mentions that no less than 1,000 additional cases of obstetrical analgesia have been handled in the Maternity Department of Evanston Hospital since his report in 1918. He has no occasion to modify the appended views expressed at that time.

CONDITION OF BABIES AT BIRTH.—"The condition of the babies at birth was carefully observed. Thirty-two babies were recorded as having been born *asphyxiated* to a greater or less degree. In some of these the notation indicates that the child was born in *fair* condition. All cases in which the condition of the baby was other than *good* are included here. Upon looking up the records of these cases it was found that in 12 cases some reason for asphyxia, other than anaesthesia, existed. In 7 cases forceps operations had been done, in one case a breech extraction and one case was a threatened eclampsia with induction of labor. One child was born with spina bifida of large size, involving the lumbar region, the tumor being the size of a small orange. This child lived only 3 days. In one case there was a severe degree of toxaemia of pregnancy, the blood pressure going up to 160 mm., and the child, when born, weighing only 2½ pounds. The placenta in this case showed very extensive pathological alteration, only about 1/3 of the placenta area being in a condition to functionate and the child's development *in utero* had evidently been stunted through deficient blood supply. One case was a premature labor. We have, therefore, 20 cases that may be regarded as showing more or less asphyxia. * * *

"Six babies were *stillborn*. In looking up the histories of these cases it was found that one was a premature labor at six months, the heart sounds being inaudible at the onset of labor. One was a hydrocephalus. One was a face presentation with the head not engaged which was delivered by podalic version, followed by forceps on the after-coming head. One was a craniotomy, necessitated by a contracted pelvis. Two others were breech presentations. One of these was a version which was done for a transverse presentation. In these six cases we find causes incident to the labor or delivery which are sufficient to explain the foetal death. *No case of foetal death, therefore, has occurred in this series in which the death seemed fairly chargeable to the analgesia.*"

The question has been raised, recently, by Ferguson as to whether the use of nitrous oxide may cause haemorrhage of the newborn.

During the time covered by Danforth's series there were a number of cases of haemorrhage of the newborn. They seemed to come in groups, five in the fall of 1916 and four cases during March and April, 1917. No explanation is offered for this appearance in groups.

"Of the four cases," writes Danforth, "which have appeared recently, two were perfectly normal cases, one being a rapid delivery with only 15 minutes of analgesia. The other two were forceps deliveries and one of these children bled from a wound in the scalp, caused by the forceps, from the bowel, nose and from the prick of a hypodermic needle. *In the maternity in which these cases were observed there have been no more cases of haemorrhage in the newborn since the adoption of nitrous oxide than there were before. In the light of all information which is obtainable it seems safe to conclude that nitrous oxide is no more likely to produce haemolysis or haemorrhage than any other anaesthetic agent.* * * *

PUERPERAL INSANITY.—"Two of the parturient women in this series of cases, developed puerperal insanity. Both of these were primiparae, one thirty-two, the other thirty-five years of age. One of these received nitrous oxide for 1½ hours and the other for 30 minutes. Both received 10 per cent of oxygen with the nitrous oxide. One of these was a patient of a physician who comes but rarely to the hospital and could not be traced. The subsequent course of the other was ascertained. She left the hospital on the tenth day, having developed her neurosis about the third day. She was not violent, her mental aberration taking the form of mild melancholia and sullenness, which continued after she went home, but cleared up in a month and she has been well ever since. She had a history of a *previous* neurotic condition. There was no evidence of toxaemia or infection in this case, and I believe we can fairly say that the 30 minutes of analgesia had no part in the production of her mental disturbance. * * *

"No exact statement is made as to the influence of the use of gas analgesia upon the frequency with which forceps have been used. This is because many of the cases in the Evanston Hospital Maternity are delivered by men who are not members of the attending staff, hence it is difficult to assume that the indications for their use would be exactly the same in the minds of these different individuals. However, the analgesia in every case has been administered by

the permanent staff of the hospital on duty in that division. Hence the administration of analgesia is exactly the same in its technique, whether the remainder of the case conforms to a given standard or not."

Other Available Statistics.—Charles S. Bacon, of Chicago, reports the following results from a study of 200 administrations of nitrous oxide in labor and operative obstetrics:

"The duration of analgesia was 0 to 1 hour in 75 cases; 1 to 2 hours in 75 cases and 2 to 4 hours in 50 cases. The results of analgesia were good in 140 cases, fair in 50 cases and poor in 10 cases. The following complications presented in 8 cases each, nephritis, heart lesions, tuberculosis, and eclampsia. * * *

"Morphine or codeine with atropine or scopolamine was given by way of preliminary medication for the labor pains of the first stage. Analgesia was rarely begun before the second stage. Individual pain administration was the method of use in all instances of spontaneous labor. Continuous analgesia was used in operative interference and nitrous oxide-oxygen anaesthesia for delivery, supplemented by etherization. * * *

"Pink babies numbered 170 at birth while 30 were blue. There was no difficulty in resuscitating all of them, and there was no indication that analgesia or anaesthesia was responsible for the varying degrees of asphyxia. There was no immediate mortality of the newborn. * * *

"The duration of labor was shortened in 20 cases, normal in 130 cases and delayed in 50 cases. There was no shock to the parturient mothers nor any immediate or delayed maternal mortality. Involution was prompt and no increase of portpartum haemorrhage was noted. Maternal recovery, the appearance of lactation and the duration of the puerperium were normal. * * *

"The effect of analgesia and anaesthesia on the foetal heart seemed to depend on the character of the uterine contractions. If the foetal heart beats were slowed or increased by the uterine contractions the anaesthetic generally limited the retardation or the acceleration. It seemed to have a stabilizing influence. * * *

"Medium and low forceps were used under nitrous oxide-oxygen alone or with supplemental etherization when required. External, internal and cervical

lacerations were repaired under nitrous oxide-oxygen, while abdominal and vaginal Caesarean section were done under nitrous oxide-oxygen-ether anaesthesia."

Robert I. Dickinson, of New York City, reports the following results from a study of 100 administrations of nitrous oxide to private patients in labor and operative obstetrics:

"The duration of analgesia was usually from 2 to 3 hours and the results were uniformly good. Nephritis, heart lesions and eclampsia presented as complicating factors in a few instances. Morphine and scopolamine were given to alleviate severe pain during the first stage of labor, especially in neurotic primiparae. Individual pain administration was the method of analgesia used in all cases. Continuous analgesia was only employed during expulsion or extraction of the head, and supplemental etherization was used during delivery only occasionally and when absolutely required. * * *

"Only three babies were partially asphyxiated at birth, and all were easily resuscitated. There was no immediate or delayed infant mortality although forceps were used in several cases. * * *

"The most marked advantage of this form of pain-relief noted is the markedly lessened incidence of postpartum haemorrhage under nitrous oxide as compared with chloroform. * * *

"Nitrous oxide-oxygen was used during cleaning-out the uterus after abortion, as well as during the use of low forceps and the repair of external lacerations."

Katharine Harrington, of Chicago, while anaesthetist on the service of N. Sproat Heany, at the Presbyterian Hospital, collected the following statistical records of 200 administrations of nitrous oxide in labor and operative obstetrics:

"The duration of analgesia was 0 to 1 hour in 5 cases; 1 to 2 hours in 10 cases; 2 to 3 hours in 10 cases; 3 to 4 hours in 75 cases; 4 to 5 hours in 75 cases and 5 to 6 hours in 25 cases. The results of analgesia were uniformly good in all cases. Heart lesions were encountered as complicating factors of labor in 2 instances. * * *

"No preliminary medication was used. Individual pain administration of analgesia was begun toward the end of the first stage and continued throughout the second stage in all cases. Continuous analgesia was not used. When indicated for relaxation or other requirements nitrous oxide-oxygen anaesthesia was used, supplemented by ether in 75 cases. * * *

"The foetal heart was slowed in two instances in which the mothers became cyanotic. Pink babies numbered 180 at birth while 20 were more or less blue. All were resuscitated and no stillbirths occurred. There was no immediate infant mortality and the three delayed deaths in the series were in no way due to nitrous oxide. * * *

"Malpositions accounted for delayed labor in 30 cases, dystocia in 2 cases and labor was slow in 30 cases. Medium forceps were used 7 times and low forceps 18 times. Caesarean section was done 3 times under ether. * * *

"Involution was prompt in 195 cases and delayed in 5 cases. Postpartum haemorrhage occurred three times. Shock was absent and there was no immediate or delayed maternal mortality. Maternal recovery was normal in 192 cases, on the eighth day, while recovery was slightly delayed in eight cases. Lactation was normal in 170 instances and delayed in 30. * * *

"There were 80 primiparae and 110 multiparae in the series. 190 external and 180 internal lacerations were repaired under nitrous oxide-oxygen anaesthesia. Supplemental ether was used three times in the repair of cervical lacerations."

CHAPTER NINE
Operative Obstetrics

Nitrous Oxide-Oxygen in Operative Obstetrics ❧ General Considerations ❧ Pathological Conditions of Patients as Complicating Factors of Pregnancy, Labor and Operative Obstetrics ❧ Operations During Pregnancy ❧ Gall-Bladder Operations. Appendicitis and Pelvic Infections ❧ Tumors ❧ Abortions, Miscarriages and Ruptured Ectopic Gestations ❧ Heart Lesions. Tuberculosis ❧ Sapraemia and Sepsis ❧ Syphilis ❧ Nephritis, Eclampsia and Toxaemia ❧ Supplemental Etherization ❧ Precipitate Labor and Uterine Inertia ❧ Rigid Perineum and Episiotomy ❧ Forceps Delivery ❧ Repairs ❧ Nitrous Oxide-Oxygen and Combined Anaesthesia for Caesarean Section ❧ Alkaloidal Medication ❧ By Whom Shall Nitrous Oxide Analgesia and Anaesthesia be Administered ❧ General Conclusions ❧

THE MORE FREQUENT USE of anaesthetics in obstetrics, while affording surgical relief for dystocia, the correction of mal-position by manipulative skill and the repair of injuries to the soft parts, has in recent years stimulated a search for a more ideal and flexible narcotic agent in this field, and after ten years of routine use, McKesson has adopted nitrous oxide-oxygen for all obstetrical operations and has used it *alone* almost exclusively, as the anaesthetic of choice, during the past eight years. In this connection McKesson emphasizes that:

General Considerations.—"Operative Obstetrics presents differences in anaesthesia and surgical technique, from the usual surgical operation, which are too frequently ignored. There is more than the mother's general condition to be thought about during anaesthesia: there is the mother in a general sense, the uterus and birth canal in particular, as well as the foetus.

Ether for operative obstetrics cannot be administered *ad libitum*, as is sometimes done in a surgical clinic. Such use does not fit into obstetrical requirements, but leaves the uterus incapable of further immediate labor, should such be desired; and the reaction of the child, if born under profound ether, is often sluggish, if breathing begins at all. * * *

"*These points are familiar to all but are emphasized here because parturient women are so often treated as purely surgical cases with disastrous results.* Those anaesthetists and obstetricians, who have seen only such operative cases in obstetrics as Caesarean section, have missed the many obstetrical manœuvers, in which the transient anaesthesia of nitrous oxide-oxygen aids the art and skill of the obstetrician in avoiding surgery and relieving the mother of much pain and shock, and delivering the child without recourse to the knife. The mother may be anaesthetized for a rotation of an occiput posterior or a version and within two minutes after completion of the manœuver and removal of the inhaler, be awake and resuming labor. * * *

"Many noted obstetricians who have been accustomed to using nitrous oxide-oxygen *analgesia* have not employed these gases for complete anaesthesia. In many instances nitrous oxide-oxygen has not been selected for obstetrical operations because of erroneous impressions and views gained from older writers and misinterpretations of the mechanism of its anaesthetic action. One of these mistakes is the impression that nitrous oxide-oxygen anaesthesia increases blood pressure. A sphygmomanometer, used as a routine during operations, as I have done for 12 years, will demonstrate the fact that nitrous oxide-oxygen does not increase blood pressure and is not contraindicated in any case of arteriosclerosis, eclampsia or nephritis, as has so often been repeated from one author to another until the literature has become permeated with the error. Another is the false impression, based upon the old and exploded asphyxia theory, that nitrous oxide-oxygen anaesthesia causes *blue babies.* * * *

"Nitrous oxide is a true, specific anaesthetic and may always be administered, in operative obstetrics, with sufficient oxygen to prevent cyanosis and anoxaemia of both mother and child, as effectively as if no anaesthetic at all were given. As a matter of fact the oxygen element in this method of anaesthesia is a great protection against untoward incidents during operative obstetrics. * * *

"Whether the crusade against vaginal examinations, if followed out, will benefit parturient women generally, by lessening infection in a contaminated field, or implies that physicians are unable to diagnose the position of the child and the progress of labor, when they do examine, is far from clear. *The important factor is that mistakes in diagnosis of the situation in the birth canal delay the institution of proper treatment, if applied at all, before the foetus is dead or the mother reduced to a state of invalidism.* * * *

"How many times a Caesarean section is found to be necessary after the mother has exhausted herself, traumatized her pelvic tissues and lost her baby! Can the kind of anaesthesia then employed be blamed for the dead baby, postpartum haemorrhage or puerperal fever? No, but it may be a contributing or even deciding factor in some such cases. * * * .

"It has been argued by some that nitrous oxide-oxygen anaesthesia does not relax musculature sufficiently. However, sufficient surgical relaxation, for hysterectomy, gall-bladder, stomach or any other abdominal operations, is being accomplished not only in my own work, but also by many other anaesthetists, *without the addition of ether.* Moreover, one of the most important things, in obstetrical operations, is the maintenance of muscular tone by employing as light an anaesthesia as is consistent with the requirements of the operative procedure. It is well to bear in mind, as has been previously suggested, that anaesthesia administered to full muscular relaxation not only reduces muscular tone in the abdominal and other skeletal muscles but similarly affects all kinds of musculature in the body; be it of the uterus, heart, blood vessels or intestines. * * *

"Each group shows its peculiar reaction to profound anaesthesia: If uterine, relaxation and haemorrhage; if cardiac, inefficient circulation; if circulatory, lowered blood pressure; if intestinal, flatus and adynamic ileus may result. The fact that extreme muscular relaxation, which causes the mentioned pathological changes, is very difficult to obtain with nitrous oxide-oxygen, shields the mother from these phenomena which are sometimes combined in their occurrence in the same patient. * * *

"*If there is, at present, an ideal anaesthetic for obstetrical operations, nitrous oxide-oxygen is this agent.*"

Pathological Conditions of Patients as Complicating Factors of Pregnancy, Labor and Operative Obstetrics.—Such pathological conditions as pernicious vomiting, nephritis, heart lesions, tuberculosis. eclampsia, haemorrhagic states, sapraemia, sepsis, syphilis and other complicating factors may materially add to the difficulties of the anaesthesia problem in operations during pregnancy, analgesia during labor and anaesthesia during operative obstetrics. Also such conditions as uterine inertia, too precipitate labor, dystocia, mal-position, tumors, and other complications may still further beset those concerned in the safe delivery of the child and the saving of the mother's life. In practically all complicating factors nitrous oxide-oxygen analgesia or anaesthesia *alone*, if expertly given or with supplemental etherization in the hands of the less skilled, will more satisfactorily meet the surgical or obstetrical requirements and more absolutely safeguard the two lives involved than any other method of pain-relief.

Operations During Pregnancy.—It is not infrequently necessary for surgeons and gynecologists to operate on pregnant women for gall-stones, appendicitis, pelvic infections, tumors, abortions and miscarriages, not to mention ruptured ectopic gestations.

Gall-Bladder Operations. — That nitrous oxide-oxygen is the anaesthetic of choice in gall-bladder surgery, especially when associated with jaundice, goes without saying. Its use, for hours without untoward effect, to relieve the excruciating agonies of gall-stone colic, bespeaks its safety and efficiency. Also the fact that nitrous oxide babies show a decreased incidence of *icterus neonatorum* indicates the minimal effects of this agent on liver function as well as catalase secretion, as shown by Burge. Also some years ago Horace J. Whittaker, then of Cincinnati, now of Tacoma, was able to save eight patients out of ten, operated on for rupture of the gall-bladder under nitrous oxide-oxygen anaesthesia, although all the patients were in a more than hazardous condition at the time of operation.

Appendicitis and Pelvic Infections. — Patients presenting these complications during pregnancy are naturally highly acidosed, dehydrated and occasionally secondarily shocked from the effects of sepsis or a ruptured appendix. As has been shown in war surgery these conditions are best combated, as far as anaesthesia is concerned, by the use of nitrous oxide-oxygen, associated

with rehydration with alkalies, sugars, carbonated fruit juices and carbohydrate diet, aside from the necessary operative procedure.

Tumors.—Occasionally a fibroid tumor complicates pregnancy. In non-pregnant women the removal of a fibroid is often attended with permanent circulatory depression, if the stimulation of etherization is provoked by rough surgery to the point of heart-load collapse. Also there would seem to be an element of pituitary exhaustion connected with fibroid tumors and their removal. On account of its conservation of muscle tone and cardiac force, nitrous oxide-oxygen is the safeguarding anaesthetic for this operative procedure, both in the pregnant and non-pregnant woman.

Abortions, Miscarriages and Ruptured Ectopic Gestations. —For evacuation of the uterus in cases of incomplete abortion, or for the introduction of packing in cases of inevitable miscarriage or therapeutic abortion, nitrous oxide-oxygen is the desirable anaesthetic, according to Danforth, who writes that: "In the hands of a competent anaesthetist sufficient relaxation may almost invariably be obtained for handling these conditions, without the addition of ether, and in these cases rebreathing may be used if needed. Cases of this character I have done with nitrous oxide-oxygen anaesthesia for some years prior to the time we began to use it in obstetrics, and during the past five years I have used supplemental ether in cases of this sort probably not more than a half-dozen times."

Guedel has also found nitrous oxide-oxygen *analgesia* rather routinely satisfactory for emptying the uterus, following incomplete abortions. Occasionally *anaesthesia* is required when the cervix needs to be thoroughly dilated.

In meeting the problems inherent in the handling of ruptured ectopic gestations, great discretion must be used, by both the operator and anaesthetist, in either combating shock, due to rupture and haemorrhage before operating, or else in waiting for the recovery period before interfering. Cannon, in his researches on the relation of anaesthesia to shock and haemorrhage, has shown how and why nitrous oxide-oxygen is indicated as *the* anaesthetic in such conditions as ruptured ectopic gestation, and has emphasized the necessity of percentages of oxygen, in the anaesthetic mixture, proportionate to the intensity of shock and the degree of exsanguination, in order to save life.

It is also interesting to know that all observers have noted an influence on the part of nitrous oxide-oxygen to abate pernicious vomiting. Incidentally it may also be mentioned that vomiting after nitrous oxide-oxygen anaesthesia, for surgical or obstetrical procedures, is much less frequent and severe than after ether or chloroform anaesthesia.

Heart Lesions.—The very slight effect of nitrous oxide-oxygen on blood pressure, the cardiac and circulatory musculature and the organic functions of the body, makes it the anaesthetic of choice in cardio-vascular lesions and degenerations complicating pregnancy, labor and operative obstetrics. W. D. Gatch, of Indianapolis, while studying nitrous oxide-oxygen rebreathing, in the surgical clinics of the Johns Hopkins Hospital, found nitrous oxide-oxygen anaesthesia of especial value in such cardiac risks as had to be maintained in a semi-sitting posture during operation, on account of their heart or circulatory condition. It is one of the striking advantages of nitrous oxide-oxygen anaesthesia that it may be safely given to patients in *any position* required by any surgical operation or obstetrical procedure. Gettman, of Buffalo, has recently recounted similar experiences, although one of his cardiac risks died suddenly in bed, 9 days after delivery, a danger which remains, irrespective of all the precautions taken by the obstetrician and anaesthetist.

In connection with the relation of cardiac risks to anaesthesia and operation, readers of this Monograph will be glad to learn that, in pursuing his researches on a safe and satisfactory method of securing adequate surgical relaxation under nitrous oxide-oxygen, McKesson has found a method of determining the patient's operability by blood pressure reactions during primary and secondary nitrous oxide saturation; that he and Waters have been able to use this test in eliminating certain cardiac cases as operable risks, and that in each instance the patients, who were denied operation, died within a few months from the effects of their circulatory condition. As the reliabliity of this test is developed the National Anaesthesia Research Society hopes to give its technique and use wider publicity.

Tuberculosis.—Obstetricians are more and more coming to the realization that tuberculosis is one of the most important complicating factors of pregnancy, labor and operative obstetrics. For a time it was thought that W. E. Savage, of Cincinnati, had found in the closed cone method of etheriza-

tion a more or less specific therapy for incipient tuberculosis as well as tubercular meningitis and peritonitis. In continuing the experimental work of Corper, Brown and Petroff, J. B. Rogers, of the Percy Shields Research Laboratory and Ernst Zueblin, of the Cincinnati Tuberculosis Sanitorium, have found that ether anaesthesia in tuberculously infected guinea pigs fails to exert any inhibitory action on the progress of the tubercle formation or to prolong the life of the animal. Neither does ether anaesthesia raise the resistance of tuberculously infected guinea pigs. The danger of harming positive sputum cases of pulmonary tuberculosis, by causing aspiration of the infected material into non-infected areas, as well as the direct irritating effects of ether on the inflamed pulmonary tissue, must not be overlooked, as it is represented by a decided flare-up of the patients after surgical operations under ether.

In a new series of "Studies on the Effect of Nitrous Oxide-Oxygen on Experimental Tubercle Bacillus Infections," just completed as this Monograph goes to press, J. B. Rogers has reached the following conclusions:

1. Nitrous oxide-oxygen anaesthesia, administered daily to guinea pigs suffering from pulmonary tuberculosis, does not influence the development of the disease, neither is it detrimental to the general health of the animal.

2. Since these gases do not cause as much labor in respiration as etherization and are less irritating to pulmonary tissues than ether, they can be considered more suitable for anaesthesia, when used in cases of pulmonary tuberculosis and other respiratory diseases.

W. J. Hunnicutt, of Asheville, who has had very extended experience in anaesthetizing the frankly tuberculous for operative procedures, favors the routine use of nitrous oxide-oxygen on account of its markedly less tendency to stimulate latent foci or to exacerbate the existing condition. Tuberculous subjects should be handled with a great deal of discretion and the utmost care as to their welfare under anaesthesia or analgesia.

Sapraemia and Sepsis.—Again, the researches of Cannonn and the clinical experiences of Marshall have shown the superiority of nitrous oxide-oxygen anaesthesia over etherization in the presence of such complicating factors as sapraemia and sepsis. These conditions induce an acidosed state of the patient which is aggravated by etherization even with oxygenation.

Syphilis. — In working on the development of ethylene ether, J. H. Cotton noted that syphilis was one of the pathological conditions in which it was difficult to induce *analgesia* and maintain it with any degree of satisfaction. So little is known about the relation of syphilis and its reactions to anaesthetics and anaesthesia that it is hoped some one will conduct sufficient researches in the matter to arrive at some definite conclusions.

Nephritis, Eclampsia and Toxaemia.—Wm. de B. MacNider, of Chapel Hill, N. C., has shown in recent researches that chloroform anaesthesia, in the presence of chronic nephropathy in dogs, is inclined to render them anuric, and under certain conditions that this anuria is not remediable by the use of such diurectics as theobromine, caffeine and pituitrin. While the effects of chloroform on the suppression of renal function may be somewhat counteracted by alkalinization, even this method is not always reliable in its results.

S. P. Reimann, of Philadelphia, and his co-workers have found a very high percentage of acidosis in the post-operative cases of Deaver's clinic, all of which had been operated under ether anaesthesia. Yandell Henderson, of New Haven, Conn., has found that prolonged etherization or extended induction periods with struggling, induce very low levels of alkali reserve. R. C. Coburn, of New York City, has observed that the deleterious effects of profound etherization may be and should be combated by the inhalation of carbon dioxide post-operatively. There would seem to be a certain relation between the bodily reactions of aviators in altitude flights to low tensions of oxygen that resemble certain pathological states and reactions to anaesthesia.

Undoubtedly many of the undesirable effects of chloroform and ether anaesthesia, in the presence of such complications as nephritis, eclampsia and toxaemia, may be partially obviated by preliminary alkalinization and the concomitant use of oxygen, but such precautions are seldom used and are not routinely dependable.

On the contrary nitrous oxide-oxygen, which induces the mildest possible degree of anaesthetic acidosis, conserves carbon dioxide content and gives more than adequate oxygenation at all times, is, by these very characteristics, indicated in preventing the usual effects of other anaesthetics on patients suffering from nephritis or who are in the throes of eclampsia or toxaemia.

The fact that anaesthetists and obstetricians are using nitrous oxide-oxygen, more frequently in the control of the convulsions of eclamptic seizures, with success and without harmful effects, indicates its peculiar value when operative interference becomes necessary.

SUPPLEMENTAL ETHERIZATION. — When the use of supplemental etherization with nitrous oxide-oxygen is deemed advisable by the anaesthetist, operator or obstetrician, it should be remembered that an ounce or so of ether *per hour* may be given without entirely dissipating the unique advantages of nitrous oxide-oxygen anaesthesia *alone*. In most instances, in which supplemental ether is called for, so little need be given to procure the results desired, that the method of anaesthesia really remains a nitrous oxide-oxygen one. It is always advisable to discontinue the use of ether as soon as possible and perform the final part of all operative procedures under nitrous oxide-oxygen alone and then to thoroughly oxygenate the patient to the point of complete recovery. In this way any tendency toward delayed effects of etherization may be obviated. Similarly, when nitrous oxide is not at hand, ether should be given with oxygen and the remnants of the ether washed from the system by a thorough rebreathing of oxygen and carbon dioxide at the end of operation.

PRECIPITATE LABOR AND UTERINE INERTIA.—Nitrous oxide-oxygen may be given during any stage of labor according to existing conditions. The usual time for beginning analgesia is at the end of the first stage or the beginning of the second stage, when about 2 or 3 finger breadths dilation of the cervix has occurred, and labor pains are taking place every 5 or 6 minutes. However, it may be begun sooner if uterine contractions are well established and quite severe.

According to Chas. K. Teter, of Cleveland, there are some women, so imbued with the idea that all the sensations of labor must be absolutely eliminated from the very beginning, that they insist on being placed in a state of utter oblivion to their condition, regardless of consequences, and will scathingly denounce all concerned, not only at the time but forever after, if their request be not granted.

Theoretically, continues Teter, there may be some danger of *retarding labor* if analgesia is begun during the first stage, or if analgesia be carried too

deeply, but uterine inertia has never occurred in any of his cases, nor has Teter noted that the first stage has been prolonged by the use of nitrous oxide toward its close. The second stage is usually shortened, especially in multiparae, who may deliver themselves under nitrous oxide far more rapidly than is expected.

In cases in which labor is inclined to proceed too rapidly and there is danger of laceration, unless labor is delayed, this may be quickly accomplished by deepening analgesia so as to obviate all conscious expulsive efforts of the mother, without interfering with the actual force of the normal uterine contractions.

When the head is on the perineum it is generally advisable to carry the patient into light anaesthesia, although many cases will go to complete delivery during analgesia without appreciating any pain. As stated by Lynch and Webster "it is a remarkable sight to see the head widely distending the perineum with no evidence of pain and the mother able to respond to the suggestions of the operator."

Guedel has also found that in most cases the state of analgesia suffices even through the period of birth, but in precipitate labor or whenever there is any likelihood of laceration, he holds back the head and delivers *between pains*, when this is possible.

In handling the stage of expulsion, Danforth, as the end of the second stage approaches, permits a little more nitrous oxide-oxygen with each pain and at the time of delivery, for the last 3 to 5 pains, is in the habit of adding some ether to the mixture through the apparatus. He finds that this promotes relaxation, makes it easier to control the head and delivery may be accomplished without the patient being at all conscious of it.

While nitrous oxide-oxygen cannot prevent dystocia from a disproportion or a mal-presentation, Davis is of the opinion that it does lessen the dangers from maternal exhaustion and uterine inertia without an increased risk to the child.

For the simple operation of inducing labor or hastening cervical dilatation by the introduction of the hydrostatic bag, nitrous oxide-oxygen, in the experience of Danforth, provides an ideal pain obtundent. Complete relaxation is ordinarily not needed and hence extensive rebreathing is not necessary. How-

ever, should rebreathing to a moderate degree be required, inasmuch as delivery is still far off, it may be used, as any haemolysis of foetal blood is done away with during the succeeding hours of labor; and should rebreathing be feared the mother may be given a little oxygen at the termination of the anaesthesia. Usually a very short nitrous oxide-oxygen anaesthesia permits the bag to be introduced without pain and allows the mother to wake up without nausea and without the deadening effect upon uterine contractions, which ether produces, when it is desirable that they should be immediately begun.

When the introduction of more than one bag, in the same case, is required, anaesthesia may be *repeated* and when dilatation is complete the patient is given analgesia as previously described. With a co-operating patient, and after an explanation of the proposed proceedure beforehand, Danforth has found that *analgesia* suffices for the introduction of the hydrostatic bag in many instances.

Rigid Perineum and Episiotomy.—Whether the perineal infiltration of procaine will become a routine procedure to relax the rigid perineum to facilitate expulsion, lessen lacerations and supplement nitrous oxide analgesia, remains to be seen. This technique, advocated by C. L. Hoag, and used by him in a considerable number of cases, usually provides a relaxed and obtunded perineum for a period of from 30 to 40 minutes after the injection of the perineum and the levator ani muscles, through the mucous membrane of the everted vulval edges and a rather thorough infiltration of these tissues. If expulsion follows shortly the perineum may remain sufficiently obtunded to permit of any necessary repair without deepening analgesia or using supplemental anaesthesia. Many obstetricians have tried the method only to abandon it because its advantages did not sufficiently outweigh its inconveniences and dangers. At that, as others have suggested, the local application of procaine to the cervix and vaginal outlet is almost as effective as infiltration, but even this method has never become popular.

Episiotomy may be required for rigid perineum to facilitate delivery or to prevent bad lacerations. It may be done, when necessary, under complete nitrous oxide-oxygen anaesthesia with or without supplemental etherization, depending on the extent of the tears and the skill of the administrator. When supplemental ether is used for episiotomy it is for so short a time that it does

not produce narcosis of any imperiling length or depth and the patient rapidly awakens and is only rarely nauseated.

Forceps Delivery and Version.—It has been a matter of frequent observation that patients, who have been complaining bitterly of suffering toward the end of the first stage of labor, and have, perhaps, even become a trifle unmanageable, have almost immediately become quiet and amenable to suggestion upon beginning the administration of nitrous oxide-oxygen analgesia. Danforth feels that he has been able to carry a number of cases through a *tedious* second stage, due to one cause or another, that would usually have been terminated by *high forceps*. Many of these cases, under analgesia, have progressed to the point where simple *low forceps* sufficed for delivery. This, of course, has its effect upon the lowering of foetal mortality, as well as sparing the mother the trauma and invalidism so often associated with the high operation.

As Danforth objects to the use of rebreathing, in all obstetrical cases prior to delivery, on account of the fear of haemolysis of the foetal blood, and as *without rebreathing* it is difficult to secure a degree of relaxation which he deems necessary for the proper carrying out of even a low forceps operation, he uses supplemental etherization with nitrous oxide-oxygen or else straight ether anaesthesia for forceps deliveries. He has found so little difference in the amount of ether used by both methods that he prefers etherization *alone* to the inconvenience of having asepsis disturbed by the movements of the mother under incomplete narcosis.

On the contrary Guedel, McKesson and others have found nitrous oxide-oxygen analgesia and anaesthesia *alone* sufficient for forceps delivery.

Davis thus details his latest method of using forceps: "The axis-traction forceps are applied under nitrous oxide-oxygen *anaesthesia*. As soon as the blades are locked anaesthesia is discontinued and thereafter *intermittent analgesia* is administered as in normal labor, traction being made on the forceps while the patient assists by pulling on the straps and bearing down. The assistant may also aid by making pressure on the fundus. The blades are loosened between the contractions. The pressure from above reduces to a minimum the amount of pull which must be exerted on the head of the child and thereby lessens the danger of injury. In case the patient is a primipara

or one who has a firm perineum, a primary posterior episiotomy is made, after dilating the sphincter ani, beginning in the midline and extending a little towards the left side.

Opinion is still divided as to the advisability of attempting *version* under nitrous oxide-oxygen alone. Some obstetricians and anaesthetists have been successful in so performing version and in bettering mal-presentation, but A. J. Skeel probably represents the majority opinion when he insists on the use of a surgical degree of narcosis with supplemental etherization to secure sufficient muscular relaxation for version without danger to the mother or child.

In this connection also Guedel remarks that: "The only one of the long list of so-called *abnormal* labor cases in which nitrous oxide-oxygen *alone* will fail, is that of version. The conservation or even stimulation of uterine contractions under nitrous oxide, renders version very difficult, if not impossible without relaxants."

REPAIRS.—In Guedel's practice, also, the lacerated perineum is sutured while the patient holds herself in a state of analgesia by *self-administration.* Immediate perineal or episiotomy repair can be made under the same depth of nitrous oxide-oxygen analgesia or light anaesthesia maintained for the stage of expulsion. In deep or extensive lacerations, when a number of sutures must be introduced, anaesthesia is preferably utilized, as the tugging at the sutures in tying them is distressing to most patients, when not under complete narcosis. Danforth considers that perineal repair is a surgical operation and requires that the patient should be relaxed and quiet on the table. The patient, who is but partly asleep and struggling, interferes with asepsis and renders impossible a proper carrying out of even a simple surgical procedure. But as the child is no longer in the uterus, *rebreathing* is not objectionable and the patient may be anaesthetized exactly as though she were to have any other operative procedure and should it be necessary, occasionally, a little supplemental ether may be added. Unless the lacerations are quite extensive, Danforth repairs them immediately after delivery and before the expulsion of the placenta. Nitrous oxide-oxygen for this purpose, in his experience, has not delayed the expulsion of the placenta, except in a very few cases in which considerable ether has had to be used.

Teter suggests that, if severe pains are experienced in expelling the placenta in normal cases, analgesia may be re-established after delivery. Should it be necessary to *manually extract* the placenta light anaesthesia may be quickly induced and then discontinued upon the removal or expulsion of the placenta.

Danforth further suggests the use of analgesia for the painless removal of packings in cases of postpartum haemorrhage. He has found patients very grateful for this consideration.

Nitrous Oxide-Oxygen and Combined Anaesthesia for Caesarean Section.—In 1909, J. Clarence Webster, of Chicago, began the use of nitrous oxide-oxygen both in obstetrical and surgical operations, alone or in conjunction with local anaesthesia. In the Maternity Department of the Presbyterian Hospital, the analgesic use of nitrous oxide-oxygen, in cases of labor, had been established as a most valuable means of relieving suffering without risk to the mother or child, chiefly through the work of F. W. Lynch, N. Sproat Heaney and C. Henry Davis. Previous to 1909, Caesarean sections, whether abdominal or vaginal, had always been performed under ether or chloroform. In several cases, complicated by renal and pulmonary disease, Webster had safely carried out these operations under nitrous oxide-oxygen anaesthesia. In 1909, he performed his first abdominal Caesarean section under local anaesthesia and shortly after recommended the combined use of nitrous oxide-oxygen and local anaesthesia for this operation. He advised this combination, because it is generally expedient to make a large incision, in order to expose the separated recti muscles, for the purpose of making a satisfactory closure of the wall at the end of the operation. Besides, the extraction of the child, usually causes the mother considerable distress, under local anaesthesia *alone*, when any degree of force is required in turning or delivering. In such instances the use of nitrous oxide-oxygen anaesthesia gives rapid relief.

In writing of his results, Webster says: "In recent years I have performed more than 60 conservative abdominal Caesarean sections, either under local anaesthesia or with the combined use of nitrous oxide-oxygen. In every instance both mother and child survived. As regards maternal mortality, I cannot claim that this is a better record than that obtained when I employed

chloroform or ether, for during that period I was also fortunate in never having had a maternal death. Indeed, in all my years of practice, I have performed the conservative operation about 170 times without losing a mother. As regards infant mortality, three deaths belong to the chloroform and ether period. Two of these cases were premature infants while the other had a defective heart. In a good many instances the babies did not breathe when delivered and were restored only by artificial respiration and stimulation, especially in the presence of eclampsia as a complicating factor. * * *

"There can be no doubt that as regards the foetus *in utero*, Caesarean delivery under local anaesthesia causes the least disturbance. Next in safety, and superior in comfort to the patient, is local anaesthesia combined with nitrous oxide-oxygen as required. Next is ether, while chloroform stands last."

McKesson has also found nitrous oxide-oxygen anaesthesia entirely satisfactory for Caesarean section, but he maintains that profound anaesthesia must not be used as it is harmful, under the circumstances, to both the mother and the child, and is unnecessary. The mother may be rendered cyanotic by pushing the anaesthesia to too great a depth, the child made anoxaemic and the uterus may be paralyzed. Section should be done under *light anaesthesia*, and immediately after incision of the abdomen and uterus, pure oxygen should be given for two or three breaths. This assures enough oxygen to the child during delivery and before the cord ceases to pulsate. After the child has been delivered, anaesthesia is resumed for whatever else remains to be done. In abdominal Caesarean section, once the uterus is emptied, the abdominal walls are lax and cause no difficulty in closing under very light anaesthesia.

Ben Morgan, of Chicago, considers that in Caesarean section the anaesthesia is a major one and must be handled by an entirely competent anaesthetist. It is not at all necessary to push nitrous oxide-oxygen anaesthesia to the point of relaxation as the abdomen of a pregnant woman is sufficiently relaxed to admit of any manipulations necessitated by Caesarean section. The injection of pituitrin into the uterine wall, just after incision, as recommended by Webster, is not only efficacious obstetrically, but also materially assists in stabilizing the maternal circulation. It is not at all unusual, in Caesarean section under nitrous oxide-oxygen anaesthesia with pituitrin, to put the mother back to bed without a variation in the pulse rate.

J. M. Waugh, of Hood River, Oregon, mentions one condition for which Caesarean section may be performed to the great advantage of the mother and in which nitrous oxide-oxygen may be used to play an important preliminary role. Occasionally parturient women come to delivery, who have had a previous Caesarean section or who have, in previous labors, sustained bad lacerations with consequent scar-tissue formation in the cervix and vagina. In such patients there is danger that prolonged or difficult labor may rupture the uterine scar or that the cervical scar-tissue may impede labor or prevent delivery. In such instances it is Waugh's practice to permit a *trial of labor* under nitrous oxide-oxygen *analgesia* with the most careful observation, and if at the end of several hours there is no prospect of immediate and normal delivery, to perform Caesarean section under nitrous oxide-oxygen anaesthesia for the benefit of both mother and child.

It is another striking advantage of nitrous oxide-oxygen that it may be used as an analgesic, for some hours of trial labor, without harm; and when operative interference becomes necessary it may be continued for whatever period of anaesthesia is required and still remain *more innocuous* than any other anaesthetic. It also admits of change from analgesia to anaesthesia and almost instant reversal without the nauseating tendency of other anaesthetics.

Usually a deeper anaesthesia is required for *vaginal* Caesarean section than for *abdominal*; and while nitrous oxide-oxygen anaesthesia suffices for either operation, operator and anaesthetist should carefully consider the added risk imposed on the mother and the unborn child by the longer period of operative time; the deeper and occasional supplemental anaesthesia required, as well as the greater trauma involved in vaginal section.

ALKALOIDAL MEDICATION.—While the painful first stage of labor may be eased with heroin or morphine, either alone or combined with chloral hydrate *by rectum* or scopolamine; and while these drugs, at times may be used for a very *irritable uterus* during the second stage of labor, it must be remembered that opiates tend to paralyze the respiratory centers, and if delivery follows too soon after their use, there may be difficulty in resuscitating the child. A baby born under the influence of narcotics must be carefully watched until respiration is perfectly normal and artificial respiration and oxygenation may be required, in some instances, over rather long periods of time. All anaes-

thetics and opiates, as well as pituitrin, must be used with extreme discretion, if there is any evidence of *intra-uterine foetal asphyxia.*

That morphine or scopolamine should not be given, when delivery seems likely to occur within three hours, is conceded even by the protagonists of so-called *twilight sleep.* Preliminary alkaloidal medication may be given before operations under nitrous oxide-oxygen anaesthesia during pregnancy, but even then with due precautions for the safety of both the mother and the unborn child.

By Whom Shall Nitrous Oxide Analgesia and Anaesthesia be Administered. — While nitrous oxide-oxygen analgesia for individual pain administration and continuous analgesia and anaesthesia are becoming routine methods of pain-relief in normal labor and operative obstetrics, there is, according to Davis, considerable discussion as to how widely these gases may be employed with safety, when given by different sorts of individuals. All are agreed that any anaesthetic is best administered by the professional specialist, but this is not always possible in the practice of obstetrics.

In this connection, Guedel remarks that: "Nitrous oxide is neither inconvenient nor difficult to administer. My administrations are usually carried on by the patient herself, with the obstetrical nurse or some member of the household controlling the flow of nitrous oxide-oxygen into the bags. I have found that the patient takes the anaesthetic better under these circumstances from her own hand than from the hands of any lay attendant. The technique of self-administration of nitrous oxide analgesia in obstetrics is indeed simple. As in anything else, however, the first cases handled will not be as successful as the later ones. Skill is required in adapting the air or oxygen admixture to meet the patient's individual pain requirements, but less skill is demanded of the obstetrician or anaesthetist in securing good results with the method of self-administration than with any other. The mistake usually made by the beginner is that of giving *too much* nitrous oxide, or giving the nitrous oxide *too rapidly* throughout the pain, or permitting the patient to breathe too often, or too deeply. Personally I have found that *analgesia* by individual pain administration, with the patient holding the inhaler, suffices for the most satisfactory results in nine-tenths of the normal cases of labor."

So far as Davis has been able to determine there are no contraindications to the employment of nitrous oxide-oxygen analgesia, other than the practitioners' ignorance regarding the science of obstetrics and the administration of this agent. Any physician, capable of giving proper obstetrical care, can, in a comparatively short time, master the technique for administering nitrous oxide-oxygen *analgesia* during normal labor. A special anaesthetist is not needed except in the abnormal cases, in which some operative procedure and continuous analgesia or anaesthesia, becomes necessary. * * *

"During the earlier part of labor the patient can administer her own analgesia, and when bearing-down efforts are desired, some one else can hold the inhaler over the patient's face and keep the bags filled with gases, while the obstetrician regulates the dosage of the mixture and directs the patient's breathing of the same and her conscious co-operation. * * *

A number of my patients have administered their own analgesia for more than 5 hours. They have found this a rather delightful diversion during the long hours of wakeful labor, and some have been reluctant to give up the inhaler when strong bearing-down efforts have been desired near the end of labor. * * *

"All are agreed," continues Davis, "that when properly administered, in suitable cases, nitrous oxide-oxygen anaesthesia is safer than ether or chloroform, but many operators, anaesthetists and obstetricians maintain that nitrous oxide-oxygen anaesthesia should be avoided unless given by an expert. Having been trained in a hospital, in which nitrous oxide-oxygen anaesthesia has, for the most part, been administered by internes and *without fatalities* from its use, I cannot agree with the mentioned attitude, for during the past seven years, there has been at least one ether death in this hospital. On the gynecological service we have found it just as easy to train internes to give nitrous oxide-oxygen, as safely and as satisfactorily as ether anaesthesia, but we have remembered that nitrous oxide cannot be given according to ether principles or rules."

"When the use of nitrous oxide as an agent for the production of analgesia was first begun in the Maternity Department of Evanston Hospital," writes Danforth, "there was a tendency on the part of some to emphasize the point that its administration was exceedingly simple and to give the impression

that it might be done by any one. As my experience with it has grown, I have gone farther and farther from that point of view and, at present, I am inclined to disagree with it absolutely. A properly given analgesia does require a certain amount of technique and it has been my experience that the advent of a new interne, in the obstetrical division, has been followed, usually, by a period of poorly given analgesias; since then we have tried to train each one of them somewhat in its use. I have had no experience with the method of self-administration and much prefer to have the administration of analgesia under the observation of a competent anaesthetist at all times. * * *

"In the field of operative obstetrics nitrous oxide-oxygen anaesthesia finds a rather wide application, *when properly given*, and in that proviso we find the crux of the whole situation. Nitrous oxide-oxygen anaesthesia is exceedingly safe and in a large percentage of operative cases, surgical and gynecological, as well as obstetrical, a very satisfactory anaesthesia, when given by some one who has been properly trained in its use. It is neither safe nor satisfactory when given by some one who has not been properly trained. This opinion has been expressed before by those who have had occasion to acquire some experience with it in their operative work and after a considerable experience with nitrous oxide-oxygen anaesthesia in abdominal, pelvic, vaginal and obstetrical operations, I wish not only to agree with that opinion but to emphasize it. On my service, I do not allow any general anaesthesia for operative work to be given with nitrous oxide-oxygen, for either a gynecological or obstetrical patient, except by the hospital anaesthetist."

As Moots has repeatedly pointed out there are *other essentials* in the safe and satisfactory use of nitrous oxide-oxygen anaesthesia for operative procedures. There must be team-work between the operator and the anaesthetist and they must both understand the intricacies of its administration, the reactions of varying types of patients, and above all the limitations of the method when pitted against rough surgery. The operator under nitrous oxide-oxygen must be a master of *velvet touch* surgery.

A. J. Skeel, of Cleveland, as early as 1916, urged greater proficiency in the use of nitrous oxide-oxygen for both analgesia and anaesthesia. At that time he expressed himself as follows: "I wish to enter a vigorous protest against the advice, at present being so freely given, that any one may use

nitrous oxide in labor cases with perfect safety. Nitrous oxide is a powerful therapeutic agent with great possibilities for harm in the hands of incompetent or careless users. The statement has been made and is, I believe, accepted, that nitrous oxide in the hands of an expert is the safest anaesthetic, but the most dangerous anaesthetic, if given by a novice. Even in analgesia some knowledge and experience are necessary to secure both safety and satisfaction from its use. Moreover, the temptation to follow nitrous oxide-oxygen analgesia with nitrous oxide-oxygen anaesthesia for repair, is so obvious that I would earnestly urge all those, expecting to adopt this method, to spend sufficient time in special study of the agents they are to use, so that they can direct its administration."

CONCLUSIONS.—*While the proper use of nitrous oxide-oxygen analgesia and anaesthesia, in normal labor and operative obstetrics, may do much to safeguard the lives of both mother and child, the hope of reducing the morbidity and mortality of obstetrics, which are still appalling, as compared with the results in other phases of medicine and surgery, rests, in the opinion of McKesson, much more on the disposition of the midwife, who delivers 50 per cent of the parturient women in the larger cities, than on anything else. In this fact medicine faces a problem of vast economic importance to the public, which is singularly parallel to the problem of professional anaesthesia.*

In concluding this Monograph, as representing a co-operative scientific effort in behalf of better obstetrics and anaesthesia, the Editor is reminded of the pregnant words of Henry Ward Beecher: "We should so live and labor in our time that what comes to us as seed may go to the next generation as blossom; and what comes to us as blossom may go to posterity as fruit. This is what we mean by Progress."

APPENDIX
REFERENCES

ALLEN, H. C., Brooklyn: *American Journal of Homeopathy*, October, 1912.

ANDREWS, E., Chicago: *The Chicago Medical Examiner*, Vol. ix, 1868; ibid, Vol. x, 1869; ibid, Vol. xi, 1870; ibid, Vol. xiii, 1872.

APPLETON, PAUL, Providence, R. I.: *Boston Medical & Surgical Journal*, March 25, 1920.

BALDWIN, J. F., Columbus, O.: *Medical Record*, July 29, 1916.

BAUGHMAN: *American Journal of Obstetrics*, Vol. lxiii, 1916.

BEVAN, A. D., Chicago: *Journal American Medical Association*, Vol. lxv, 1915.

BURKHARDT, L., Indianapolis, Ind.: *Journal Indiana State Medical Association*, Vol. ix, 1916.

BRANT: *Boston Medical & Surgical Journal*, Vol. clxxiv, 1916.

CASTO, T. D., Philadelphia: *American Journal of Surgery, Anaesthesia Supplement*, April, 1918; *American Year-Book of Anaesthesia & Analgesia*, 1915-16; *Dental Cosmos*, Vol. lvii, 1915; *Dental Items of Interest*, Vol. xxxviii, 1916.

CHASE, P. P., Boston: *Providence Medical Journal*, July, 1916.

CHERRY, T. H., New York City: *New York Medical Journal*, June 30, 1917.

CHRISTENSEN, H. L., Copenhagen: *Hospitalstinde*, August 11, 1915.

COBURN, R. C., New York City: *Medical Record*, February 28, 1920.

CONNELL, KARL, Omaha Neb.: *American Journal of Surgery, Anaesthesia Supplement*, January, 1915.

COPELAND, G. G., Toronto: *Canadian Medical Association Journal*, May, 1917.

COOKE: *Journal American Medical Association*, Vol. lxvii, 1916.

DANFORTH, W. C., Evanston, Ill.: *Surgery, Gynecology & Obstetrics*, March, 1916; *American Journal of Obstetrics*, Vol. lxxvi, 1917; *American Journal of Surgery, Anaesthesia Supplement*, July, 1918.

DAVIS, C. H., Milwaukee, Wis.: *Journal American Medical Association*, Vol. lxv, 1915; *Modern Hospital*, Vol. v, 1915; *American Journal of Surgery, Anaesthesia Supplement*, October, 1916; *Journal Michigan State Medical Society*, Vol. xv, 1916; *Surgery, Gynecology & Obstetrics*, Vol. xxii, 1916; *American Journal of Surgery, Anaesthesia Supplement*, October, 1917; *American Journal of Obstetrics*, Vol. lxxvi, 1917; *Painless Childbirth*, 2nd Ed., 1916, Forbes & Co., Chicago; *Interstate Medical Journal*, December, 1916; *Surgery, Gynecology & Obstetrics*, February, 1918.

DAVIS, E. P., Philadelphia: *Therapeutic Gazette*, November, 1916; ibid, February, 1917.

References

Doederlein: *Archives für Gynekologie*, Vol. xxvii, 1885-1886.

Edgar, C., New York City: *Translation Winckel's Text-Book of Midwifery*, 1890; *Journal Americal Medical Association*, Vol. lxvii, 1916.

Evans, John H., Buffalo: *American Journal of Surgery, Anaesthesia Supplement*, April, 1916.

Ferguson, R. R., Chicago: *American Journal of Surgery, Anaesthesia Supplement*, October, 1917; *Illinois Merical Journal*, October, 1917.

Findley, Palmer, Omaha: *International Journal of Surgery*, January, 1916.

Frank, L. J., Louisville: *American Journal of Obstetrics*, Vol. lxxi, 1915.

Frisbie, E. F., Albuquerque: *New Mexico Medical Journal*, June, 1916.

Geitman, W. T., Buffalo: *Journal American Medical Association*, February 17, 1917.

Gillespie, W. S., Cincinnati: *Ohio State Medical Journal*, October, 1915.

Gossett, W. B., Louisville: *Therapeutic Gazette*, February, 1917.

Guedel, A. E., Indianapolis: *Indianapolis Medical Journal*, October, 1911; *New York Society of Anaesthetists*, 1912; *Oral Hygiene*, January, 1913; *Journal Indiana State Medical Association*, March, 1915; *American Journal of Surgery, Anaesthesia Supplement*, July, 1915; *Self-Administration of Nitrous Oxide*, Lee Smith & Sons, Pittsburgh, 1913; ibid, *Author's Publication*, Indianapolis, 1916; *American Year-Book of Anaesthesia & Analgesia*, 1915-1916.

Gwathmey, J. T., New York City: *Anaesthesia*, D. Appleton & Co., New York, 1914.

Heaney, N. S., Chicago: *Surgery, Gynecology & Obstetrics*, September, 1915; *American Journal of Obstetrics*, Vol. lxxii, 1915; *Medical Record*, June 3, 1916.

Heffron, Harold, Metamora, O.: *Ohio State Medical Journal*, July, 1917.

Henderson, Elmer, Louisville: *American Journal of Surgery*, November, 1916.

Hill, I., New York City: *Journal American Medical Association*, August 19, 1916; *American Journal of Obstetrics*, February, 1918.

Hoag, C. L., San Francisco: *Surgery, Gynecology & Obstetrics*, October, 1916; *California State Journal of Medicine*, December, 1915; *Illinois Medical Journal*, April, 1918.

Irving, F. C., Boston: *Boston Medical & Surgical Journal*, Vol. clxxiv, 1916.

Kapp, M. W., San Jose, Cal.: *Medical Record*, August 5, 1916.

Kellogg, F. S., Boston: *Michigan State Medical Society Journal*, June, 1916.

Klikowitsch: *St. Petersburgh medicinische Wochenschrift*, Vol. v, 1880; *Archives für Gynekologie*, Vol. xviii, 1881.

Long, W. H., Louisville: *Kentucky Medical Journal*, Vol. xiv, 1916; *Therapeutic Gazette*, February, 1917.

Luther, E. O., Chicago: *Illinois Medical Journal*, April, 1915.

Lynch, F. W., Chicago: *Chicago Medical Recorder*, Vol. xxxvii, 1915; *Journal American Medical Association*, Vol. lxiv, 1915; *Illinois Medical Journal*, April, 1915.

Maxson, L. H., Seattle: *Northwest Medicine*, August, 1915.

References

McKesson, E. I., Toledo, O.: *Modern Hospital*, January, 1916; *American Journal of Surgery, Anaesthesia Supplement*, January, 1915; *American Year-Book of Anaesthesia & Analgesia*, 1915-1916; *Indiana State Medical Journal*, 1918; *Journal Ohio State Medical Association*, July, 1919; *American Journal of Surgery, Anaesthesia Supplement*, July, 1919.

McMechan, F. H., Avon Lake, O.: *American Year-Book of Anaesthesia & Analgesia*, 1915-1916.

Metzger: *Archives Mens. d' Obstetrique et de Gynecologie*, June, 1919.

Mobley, W. H., Detroit: *Michigan State Medical Society Journal*, June, 1916.

Mosher, G. C., Kansas City: *Missouri State Medical Association Journal*, October, 1916.

Nicholson: *Therapeutic Gazette*, Vol. xl, 1916.

Paine, A. K., Boston: *Surgery, Gynecology & Obstetrics*, February, 1916.

Palmer, C. B., San Francisco: *California State Journal of Medicine*, April, 1918.

Patterson, R., Knoxville: *Tennessee Medical Journal*, September, 1917.

Polak, J. O., Brooklyn: *American Year-Book of Anaesthesia & Analgesia*, 1915-16; *American Journal of Surgery, Anaesthesia Supplement*, July, 1919; *New York State Medical Journal*, August, 1919.

Redmond, L. C., Lexington: *Kentucky Medical Journal*, November, 1918.

Ryder, G. H., New York City: *American Journal of Obstetrics*, June, 1917.

Sajous: *Analytic Clyclopedia of Practical Medicine*, Vol. vii, 1915.

Salzer, M., Cincinnati: *Lancet-Clinic*, January 1, 1916.

Scott, R. A., Evanston, Ill.: *Chicago Medical Recorder*, June, 1918.

Skeel, A. J., Cleveland: *Journal American Medical Association*, March 11, 1916; *Ohio State Medical Association Journal*, June, 1915.

Smith, A. L., Lincoln: *Nebraska State Journal of Medicine*, January, 1918.

Spake, L. B., Kansas City: *Kansas Medical Journal*, April, 1918.

Stearns, R. W., Medford, Oregon: *Northwest Medicine*, March, 1918.

Stein, A., New York City: *American Journal of Obstetrics*, October, 1919.

Teter, C. K., Cleveland: *Lancet-Clinic*, December 12, 1914; *American Journal of Surgery, Anaesthesia Supplement*, April, 1916; *Journal American Medical Association*, Vol. lix, 1912.

Tittel: *Jahresbuch der Gesellschafft für Nature und Heilkunde*, 1882-83.

Tuckey, H. A., San Francisco: *Dental Cosmos*, April, 1917.

Turner, C. E., and Jones, W. I., Columbus, O.: *American Journal of Surgery, Anaesthesia Supplement*, April, 1918; *American Journal of Obstetrics*, December, 1919.

Wakefield, W. F. B., San Francisco: *American Journal of Obstetrics*, May, 1918.

Webster, J. C., Chicago: *Journal American Medical Association*, March 6, 1915; *American Journal of Obstetrics*, October, 1918.

Welz, W. E., Detroit: *Michigan State Journal of Medicine*, December, 1917.